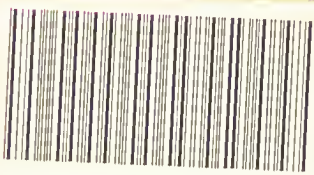
A PRACTICAL GUIDE TO THE ADMINISTRATION OF ANAESTHETICS

R. J. PROBYN-WILLIAMS

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ADMINISTRATION OF ANAESTHETICS

A PRACTICAL GUIDE

TO THE

ADMINISTRATION OF ANAESTHETICS

BY

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PREFACE

TO

THE SECOND EDITION

This book is essentially a revision of the first edition, with the addition of descriptions of methods and apparatus which have come into general use during the last few years.

Two new chapters have been devoted to Ethyl Chloride and Spinal Analgesia, and short accounts of the Vernon Harcourt Chloroform Inhaler and other new apparatus will be found.

I have considered it best to give no more than a brief note on the subject of "Delayed Chloroform Poisoning" and "Status Lymphaticus."

My thanks are due to Mr. Arthur Durand for several new illustrations which he has drawn for me; to Messrs. Mayer & Meltzer, Krohne & Sesemann, Griffin & Co. and Down & Co. for the use of blocks illustrating apparatus; to Mr. Bernard C. Scott for suggestions; and to Mr. G. H. Longton for help in the reading of proof-sheets.

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13 Welbeck Street, Cavendish Square, W.
May 1909.

PREFACE

TO

THE FIRST EDITION

WHILE teaching the practical administration of anaesthetics I have constantly been asked to recommend a small book on the subject; for at present the average student neglects the larger ones, and either reads nothing at all, or perhaps glances through the article on "Anaesthetics" in some text-book on Surgery.

It is with the object of supplying all the essential points in as small a form as possible, and not with any idea of rivalling the larger manuals by Dr. Hewitt and Dr. Dudley Buxton, that I have written this little book, in the hope that it may meet the needs of students, and be read by them during the period in which they receive their practical instruction in this branch of medical practice.

My best thanks are due to Dr. Dakin and Mr. Arthur Durand for very kindly drawing the illustrations for me; to Dr. Silk, Dr. Dudley Buxton, Mr. Carter Braine, Mr. Paterson, and Messrs. Mayer & Meltzer, Barth & Co., and Montague, for the use of blocks illustrating apparatus, etc.; and to Mr. William Turner and Mr. Harvey Hilliard for help with the reading of proof-sheets, etc.

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CHAPTER I

GENERAL CONSIDERATION OF THE ADMINISTRATION OF AN ANAESTHETIC

In the course of the following pages, whenever anaesthesia is mentioned it should be understood that reference is being made to a state of general anaesthesia produced by inhalation of one of the agents commonly employed. The general arrangements which are common to all inductions of anaesthesia, such as the preparation of the patient, etc., will first be described; then the difficulties and dangers that may be met with in connection with this artificially produced sleep; then the various anaesthetic agents will be considered in turn, and the apparatus by which they should be administered will be described; and afterwards the choice of the anaesthetic for the different classes of patients, and for special operations, will be discussed. Analgesia by local injections, and by the spinal method, will be considered in the last chapter.

Preparations of the Anaesthetist

Besides the actual apparatus for the administration of the anaesthetic, to be described later, it is important that the anaesthetist should have at hand the necessary instruments for the treatment of any accidental complications that may arise during the course of the operation. These are a gag, a wedge, mouth-props, tongue-forceps, and a case containing instruments for tracheotomy, with a hypodermic syringe, and solutions of strychnine, morphine, and

digitaline. A cylinder of oxygen, a tube for intubating the larynx, and some capsules of amyl nitrite, will also be useful.

The Gag.—The best form of gag is Mason's (Fig. 1), with ring and slide adjustment, and with a fair amount of separation between the two arms when fully open. It is made entirely of metal, and the extremities of the arms should

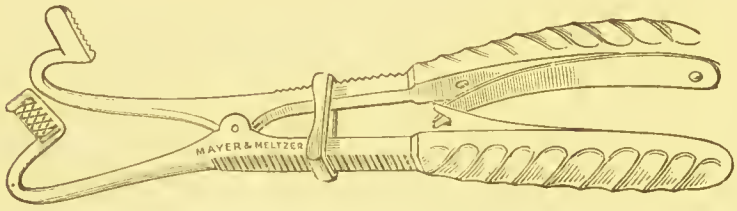

Fig. 1.—Mason's Gag

be protected with india-rubber tubing, or lead should be inserted on the tooth plates.

The Wedge.—When the jaws are tightly closed, a wedge is very useful in obtaining enough space between the teeth for the insertion of the gag. The wedge may consist of a

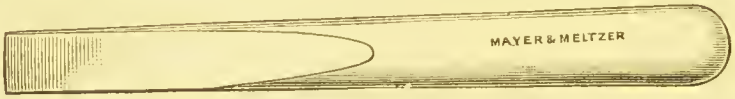

Fig. 2.—Wooden Wedge

tapering piece of smooth hard wood (Fig. 2), or may be made of metal, and hollowed to fit over a finger.

Mouth-props are generally only required in dental work, and are described on p. 66. If, however, it is desirable that the mouth should be kept open for a long period during the course of an operation, a mouth-prop may be found more convenient than a gag.

Tongue-forceps (Fig. 3) do not vary much in pattern, but there should be a sufficient number of slots on the ratchet for the regulation of pressure on the tongue.

Time of Day for Operation

The best time for the performance of a serious operation is undoubtedly in the early morning, about nine o'clock The patient may be expected to have awaked after a more or less refreshing sleep, and to be in what has been called the state of "greatest vitality." Should the early morning for some reason be unsuitable, the next best time is the early afternoon, preferably about two o'clock. In the case of children the early morning is especially to be preferred,

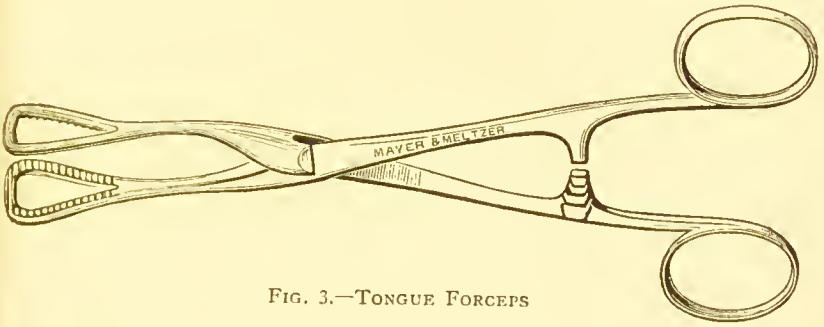

FIG. 3.—TONGUE FORCEPS

as they may then be kept in ignorance of any unusual occurrence till the actual time of the operation.

Preparation of the Patient

When called to administer an anaesthetic, there is seldom time or opportunity for the anaesthetist to suggest any details in the preparation of the patient, but he should be prepared to give advice when called upon.

A patient who has been confined to bed for some days will, as a rule, take an anaesthetic much better than one admitted on the day of the operation, in other words, the rest, and regulation of the diet, etc., which precede the operation are beneficial. For all serious operations it is important that the patient should be carefully prepared, and neglect of the proper precautions may give rise to trouble, either during the operation, or afterwards. Small

doses of strychnine given for two or three days before a serious operation are often beneficial.

A *purgative* should always be given on the previous evening, to be followed, if necessary, by a simple enema in the morning. In choosing an aperient the patient should be studied, and one that is usually satisfactory to him may be selected. Very free purgation is unnecessary, and even injurious to the patient, as the night's rest may be spoilt, and the patient weakened and depressed in consequence.

Diet.—This is very important, and exercises a considerable influence on the vomiting after an operation. If the time fixed is in the early morning, the last meal of solid food is best taken on the previous evening, at the time to which the patient is accustomed, probably between seven and eight o'clock. The food should be light and easily digestible, and moderate in amount. If the patient is fairly robust, and sleeps well through the night, nothing need be taken on the morning of the operation; but if he is wakeful, a little tea, or clear soup, or some meat extract with hot water, may be given between five and six o'clock; but in no case should food of any description be given within three hours of the operation. Milk given in the early morning is specially objectionable, as the dread of the operation will probably retard digestion, and the milk will be vomited in the form of curds.

When the operation is to take place in the afternoon an ordinary breakfast may be taken between eight and nine o'clock, though caution should be exercised both in the quantity and quality of the food. After breakfast nothing more should be taken. If the time chosen is not in the early morning, or early afternoon, the last meal must be so arranged that there is at least three hours' interval between the taking of the last food and the administration of the anaesthetic.

If the patient is extremely feeble it may be well to administer a little stimulant even within half an hour of the operation, but this should only be done in exceptional cases. One or two tablespoonfuls of good brandy diluted with an equal quantity of water may be taken by the mouth ; but it is better given in a nutrient enema, with two ounces of beef-tea, and an egg beaten up in it.

It is well to caution habitual smokers that they must deny themselves on the morning of the operation, and be strictly moderate on the evening before ; as the pharyngeal catarrh which so generally exists will by recent indulgence be temporarily increased, and will often cause great annoyance to the patient and anaesthetist during the early stages of the administration.

In operations on the stomach that organ should be washed out just before the anaesthetic is given ; and unless the general condition is too serious, the same procedure may be followed with advantage in any patients suffering from frequent vomiting, as in cases of intestinal obstruction, etc.

For the administrations of nitrous oxide and ethyl chloride much preparation of the patient is not necessary ; but a better anaesthesia will be obtained if no food has been taken for two hours previously, so that for dental operations the later hours of the morning and afternoon are to be preferred. It is also important that no stimulant should be taken just before the administration, as if it is the anaesthesia will be shorter.

Examination of the Patient

In examining a patient before the administration of an anaesthetic, a general inspection is often more valuable than auscultation of the chest. In cases of death from cardiac failure, it is seldom that the preliminary auscultation has suggested danger. The patient will almost

certainly be somewhat nervous, the heart will beat rapidly in consequence, and abnormal murmurs will not be easily detected. In fact, should the stethoscope reveal a cardiac murmur, that alone is of comparatively small consequence, but the supremely important question to be answered is whether the lesion is fully compensated, and whether the heart is doing its work well ; and this can be better determined by inspection, etc., than by auscultation.

The character of the pulse, the colour of the lips, and the presence or absence of breathlessness give the best indication of the condition of the circulatory system. Should these seem unfavourable, search must be made for signs of back-pressure, as oedema of ankles, and moist sounds in the lungs, and the heart should then be carefully auscultated.

The chest should be examined for signs of bronchitis, and if the patient has been lying in bed for some time, attention must be given to the bases of the lungs for signs of oedema. Emphysema must be specially noted, as when it is marked ether is not tolerated well. Whether trouble is suspected in the chest or not, it is a good plan to watch every patient take a full inspiration and expiration.

The arteries should be examined for signs of degeneration, and if they exhibit marked atheroma ether should be avoided, as it has produced cerebral haemorrhage in this class of patient.

The mouth should be examined to see that artificial teeth which are not firmly fixed have been removed, and notice should be taken of any loose teeth, as these may become dislodged if the patient closes his jaws very firmly.

All examinations of the patient should be conducted quietly and with tact, as otherwise he may be unduly frightened, and more harm than good will result.

Position of the Patient

Whatever may be the position in which the surgeon may require him to be placed during the operation, anaesthesia should be induced in one that is comfortable to the patient. If he is in good general health the dorsal position with the head turned to the right is the one to be preferred, but if this is unpleasant, there is no reason why he should not be allowed to lie on one side. With the head turned to the right the inhaler is held most naturally in the right hand, and the tongue tends to fall into the right cheek instead of towards the pharynx, where it would obstruct respiration. Most of the mucus and saliva that may be secreted will also collect in the right cheek, and will either run out of the corner of the mouth, or may be removed by the anaesthetist. If, however, the operation is to be performed on the right side of the head, neck, chest, or upper extremity, it is better that the head should be turned to the left, so that the surgeon is not inconvenienced by the anaesthetist's apparatus, and the seat of the operation is not contaminated by mucus or saliva.

By means of pillows, or by raising the upper end of the operating table, the head should be placed at such an elevation that the patient can breathe freely; and if it seem unduly high, the pillows can be removed when the patient is unconscious.

If the operation takes place while the patient is lying in bed, care must be taken, as he becomes unconscious, that he does not slip down into the middle of the bed, and the breathing in this way become obstructed through the approximation of the chin to the sternum.

Gas, ethyl chloride, and ether, may be given while the patient is sitting upright in a chair, but on no account should anaesthesia be induced in this position with chloroform or any of its mixtures, though for the purpose of the operation it may be afterwards necessary to raise the head.

If any disease of the heart or lungs renders breathing difficult, the anaesthetic should be administered in the position which the patient naturally assumes as the one of greatest comfort, and the position should not be altered till consciousness has been completely abolished. If there be a collection of fluid in one pleural sac the patient will generally lie with that side undermost, and this relative position must be strictly maintained throughout the administration.

When an operation is to be performed on the cranium the patient should be anaesthetised in the dorsal position, and when unconscious, the head should be raised gradually to the required height. If the head is jerked up quickly breathing is liable to be interfered with, and vomiting may occur, and both these accidents will produce intra-cranial congestion, which is to be avoided.

During the administration of any anaesthetic it is important that there should be no constriction of the neck or chest. All corsets should be removed, collars and shirt-bands undone, and if there be any bandage it should be cut, if it be at all tight round the neck.

The patient, especially if he be an adult male, should be advised to clasp his hands. He will then be less likely to move them during the induction of anaesthesia, and should he seem inclined to do so, they may be more easily controlled in this position.

Forcible restraint during the early stage of the administration is more likely to excite the patient than to produce any good result, and is in fact only necessary when he seems about to become too violent.

The position for a dental operation will be described on p. 68.

Under certain circumstances it is advisable that the patient should be anaesthetised in bed, and removed to a table for the operation. If this is done the removal should

be made when the patient is unconscious, but before the corneal reflex has been abolished. During the removal the anaesthetist should look after the head, and see that respiration is not interfered with.

Stages of Anaesthesia

For the convenience of description the process of anaesthesia has been divided somewhat arbitrarily into four stages, and the phenomena generally met with in them will now be described.

First Stage

From the commencement of the administration to the loss of consciousness.

The phenomena observed during this stage vary with the way in which the anaesthetic is administered, and the manner in which the patient breathes.

If the drug is gradually and carefully given, and the patient breathes regularly and satisfactorily, no induction of anaesthesia should be unpleasant ; but if the administrator is careless or incompetent, the initial stages may be unpleasant, especially if the patient is nervous and excited, and holds his breath. On the whole, chloroform or one of its mixtures is more pleasant to take than ether, unless the latter is preceded by nitrous oxide, which is quite tasteless. If the anaesthetic be given in too concentrated a form from the beginning the patient will have a feeling of suffocation, and will probably cough ; but if it is sufficiently diluted at first, and the strength very gradually increased, the patient should pass into a state of unconsciousness without being aware of any unpleasant taste or smell, even when ether is given without gas.

The feelings which the patient experiences during the first stage of any anaesthesia are much the same. There

is a general feeling of a pleasant sleepiness accompanied by pricking or tingling in the limbs, with a gradually increasing disinclination to make any movement. As the circulation becomes more stimulated and vigorous, noises and buzzing sounds are heard, and occasionally flashes of light are noticed. During this period any sounds heard by the patient will be intensified, so it is important that the room should be as quiet as possible. The ordinary conversation of bystanders is heard for some time longer than they think, and the patient will often be troubled by remarks which he was not intended to hear. During this stage any arrangement of the clothes, blankets or mackintoshes, or any surgical examination, should be discouraged, as they will probably be considered as the beginnings of the actual operation, and fear alone has produced a fatal result. The patient should not be restrained in any way during the early stages of the administration, for this may cause struggling when he becomes unconscious, but assistants should be prepared to prevent his doing any damage to himself or his surroundings.

During the first stage the pulse becomes quickened and the respirations deeper and faster, unless, of course, the patient voluntarily holds his breath. The pupils will generally be somewhat dilated, and react quickly to light.

Some nervous patients make themselves very uncomfortable by repeated attempts to vomit and retch, and by constant swallowing and endeavouring to open the mouth widely. In these cases the anaesthetic should be pushed, and the patient rendered unconscious as soon as possible.

As soon as consciousness is lost, which generally happens in a very short time if the patient breathes well from the start, there is a short period of analgesia, during which a minor operation such as the extraction of a single tooth

may be performed without the patient experiencing any pain. There may be some general impression of the removal of the tooth, but it may be absolutely painless. Practically, however, this period of analgesia is of little use to the operator, as at best it is very short, and the points of time at which it begins and ends cannot be exactly determined.

Second Stage

From the loss of consciousness to the loss of the corneal reflex

The line of demarcation between the first and second stage, namely the loss of consciousness, is not easily recognised.

It is generally supposed that consciousness is lost as the breathing becomes freer and deeper, but there is no definite line to divide the first two stages as there is between the second and third—the loss of the corneal reflex.

In this stage there is unconsciousness, that is, the patient will remember nothing that takes place during the period which elapses between his passing into this stage, and his gradual return to consciousness on recovering from the effect of the anaesthetic. Besides this loss of memory there is also loss of volition and intelligence, though there will still be some response to various stimuli. If questions are asked, a reply will often be given, but probably it will be quite unintelligible, or absurd. The patient may make the movements which are ordered, but they soon become inco-ordinate.

This second stage is known as the " struggling " stage, for in it some patients, especially those who are alcoholic, struggle more or less violently. With the struggling there is often associated singing or shouting, which, though quite coherent at first, gradually become more and more incoherent. This condition is generally more marked

with chloroform than with ether, and it is during this period that fatal cardiac syncope may occur with chloroform (see p. 49). This tendency to struggle is much more marked if the patient is forcibly held during the earlier periods of the administration. Besides the irregular movements of the struggling stage, a condition of tonic contraction of various muscles will often be noticed. The arms and legs are often rigidly extended, the breath is held through the contraction of the muscles of respiration, and the jaws are firmly clenched.

A form of regular clonic contraction is occasionally met with, more frequently in the case of ether than other anaesthetics, and known as "ether tremor." It is described on p. 136, and is generally confined to the lower extremities. It must not be confounded with irregular jerking movements of the shoulders and upper extremities, which are practically the "jactitations" seen in the administration of nitrous oxide gas when given without air or oxygen. These are asphyxial in origin, and may sometimes occur if the air supply is unduly limited during the administration of ether.

The **respiration** varies considerably during the second stage of anaesthesia. In successful cases it may show very little change in rhythm, but simply becomes deeper and freer till the third stage is reached; but it is more common for the breath to be "held" for a few seconds. This occurs as part of the muscular contraction of the "struggling" stage, and passes off as more of the anaesthetic is absorbed. If the breathing, instead of becoming deep, becomes shallow, it is probable that too much air is being allowed to the patient, and the breathing will become more satisfactory when more of the anaesthetic is given.

The breathing with chloroform will be quieter than with ether, and the shallow breathing from too free an admixture of air, which produces sleep rather than

anaesthesia, will be more common with the former anaesthetic; while with ether the breathing becomes more noisy from the congestion of the air passages and the increased secretion of mucus and saliva, which is not noticeable with chloroform.

Circulation

With ether the pulse becomes fuller and fuller, but with chloroform the depressant quality of the drug is manifested, and the pulse does not improve in character. If the struggling is marked the pulse becomes faster and smaller. This is more marked if at the same time the breath is persistently held. It is at this stage, when the breath has been held for some seconds, and when the first long inspiration has to be taken, and when too strong a vapour is presented to the patient, that a fatal overdose of chloroform may be absorbed. If the air-way is kept clear, and there is little struggling or holding of the breath, the pulse under chloroform will not change much for the worse.

The **colour** of a patient under ether will be at first flushed, but will gradually become more or less dusky from the restriction of oxygen. There will often be marked **sweating**, together with the special rash known as the " ether rash " described on p. 136.

With chloroform the face, if it change colour perceptibly, will become paler, and sweating to the extent observed in the case of ether is rare.

With ether there will often be an increased secretion of **mucus** and **saliva**, which is unusual with chloroform.

The **pupil** in this stage is large, perhaps more so in the case of ether on account of the greater restriction of free oxygen in its administration, and readily reacts to light.

The breathing gradually becomes deeper and freer, the muscles relax, and with the loss of the corneal reflex the third stage is reached.

Third Stage

The third stage begins with the loss of the corneal reflex, and is the stage of surgical anaesthesia

Respiration

In a typical case the respiration during the third stage, or in other words during surgical anaesthesia, is deep and regular, and gradually becomes more abdominal in character. It is more noisy with ether than with chloroform on account of the congestion of parts of the air-way, together with the increased secretion of mucus and saliva produced by that drug ; and the stimulating effect of the ether makes the rate of respiration also quicker. The muscular spasm referred to above will be more marked with ether, and hence it will be found harder to keep the jaw in good position, though as the muscles relax it becomes easier. With chloroform the breathing, though deep and regular in a satisfactory case, is very different from that with ether, as it is very quiet and sometimes almost inaudible ; the rate, too, is slower.

Laryngeal spasm may be met with in this stage, and is described on p. 36. If the breathing is not deep and regular during this stage the cause for this must be sought and remedied, as described in the account of the " Difficulties and Dangers of Anaesthesia " on p. 35.

Circulation

The condition of the circulation shows a marked difference according to the drug which is being administered. With ether the pulse will be found full and bounding. It is generally quite regular, and the rate is increased to between 80 and 100 beats per minute. With this stimulated circulation there may be noticed flushing of the face, sweating, especially on the forehead, and the " ether rash." The pulse of chloroform anaesthesia, when the

patient may be described as "taking the anaesthetic well," is generally about the normal fulness, and of the usual rate, or perhaps somewhat slower.

The **colour** of the face under ether will, if the air-way is clear and breathing is satisfactory, be somewhat florid, while under chloroform it is generally paler than normal. If the air-way is obstructed, and breathing is not satisfactory, the face will soon become dusky, especially with ether, and this must not be allowed.

The **pupils** should not be widely dilated, but of a moderate size, the average diameter under ether being about 4 mm., while that under chloroform is about 2·5 mm.

The pupil should react to light, and with chloroform there may be seen the unusual phenomenon of the two globes moving independently, the "unassociated movement" first described by Warner.

The **rigidity of the muscles** which occurs during the second stage lasts much longer, and is more marked in the case of ether, though eventually they may be perfectly relaxed by this drug. With chloroform the rigidity soon passes off. This is especially noticeable in the greater ease with which the lower jaw may be kept well forward in the case of chloroform, as compared with that of ether.

The **secretion of mucus and saliva** which was noticed in the second stage, becomes more and more marked in the third when ether is being given, while with chloroform any marked increase is unusual.

The principal differences in the condition of a patient under ether as compared with that of one under chloroform are due to the fact that, while ether is a powerful stimulant, chloroform is distinctly depressant in its action.

Fourth Stage

The fourth stage of anaesthesia, or *the stage of overdose*, is not separated from the third stage by any sharp line of

demarcation. But the general condition of a patient who is suffering from an overdose of an anaesthetic differs so much from that of one who is just sufficiently anaesthetised, that the onset of the fourth stage should be easily recognised.

Respiration

The breathing gradually becomes more shallow, and slower with chloroform, though with ether it is often very rapid and shallow. It will eventually stop altogether, but before this happens it sometimes becomes intermittent and jerky.

Circulation

The pulse becomes smaller and faster, till the beats can hardly be counted at the wrist, and eventually imperceptible. The face of the patient is now pale and livid in the case of chloroform, but more dusky with ether. The nose is cold to the touch, and the forehead covered with a cold sweat.

The eyelids are separated, the globes are exposed, and are often rotated upwards. The *pupils* are widely dilated, and do not react to light, and the corneal reflex is entirely absent.

A patient exhibiting all the above signs would be in a very serious condition, but there are many degrees of overdose which vary in their signs between those just enumerated and those of the third stage. In the case of ether, when an overdose is given, it must be remembered that the circulation will be affected much later than it is with chloroform ; and that though the patient may show distinct signs of a too free use of the anaesthetic, if the cause is recognised, the inhaler removed, and the proper measures taken, the patient will recover in almost every instance. With chloroform, unfortunately, irreparable damage may have been done before the serious state of

the patient has been appreciated, and all the measures that may be taken will sometimes fail to restore the patient to life.

The foregoing paragraphs indicate sufficiently the phenomena generally observed in the various stages of anaesthesia, and the resemblances and differences between the effects of chloroform and ether.

When mixtures of ether and chloroform are given the signs generally resemble those of chloroform rather than ether, with the exception that the circulation of a patient who is inhaling a mixture containing some ether should be better than one inhaling pure chloroform.

When gas and oxygen, gas and air, or ethyl chloride are being given for a prolonged operation, the general signs to a great extent resemble those of ether, though as a rule there is no excessive secretion of mucus and saliva ; but the period of induction of the anaesthesia is so short that it is not generally described in three stages.

Though the anaesthetic state has thus been divided into stages, the student must remember that this division is purely for convenience of description, and that the loss of the corneal reflex is the only definite line of demarcation between any two stages that he will always be able to recognise.

Regulation of the Anaesthesia

When once the patient has reached the third stage of anaesthesia, the attention of the administrator must be concentrated in maintaining him in a condition of unconsciousness sufficiently deep for the operation to be performed. To do this he must observe the following :

1. Respiration.
2. Pulse.
3. Colour of the face.
4. Size of the pupil.
5. The presence of the corneal reflex.
6. Muscular movements.

1. Respiration

The character of the breathing is one of the most important guides in maintaining anaesthesia. When the patient has once passed into the third stage the breathing becomes deep and regular, and the anaesthetist must endeavour to keep up this rhythm without any intermission. He must listen carefully when the first incision is made, and if the breath is not held, he will know that the patient is sufficiently under the influence of the drug; but if it is held, more of the anaesthetic will probably be required, and some stimulation of the respiration, by rubbing the lips with a towel, may be necessary to restart the rhythm which has been interrupted. For this purpose the inhalation of a few breaths of strong ammonia has been recommended.

The more perfect a watch the administrator keeps on the respiration, the sooner will he learn to detect, by changes in it so slight that they might escape an ordinary observer, that all is not going well, and valuable time may sometimes be saved, and accidents prevented. The breathing with ether is so loud that there is no difficulty in hearing it, but with chloroform it sometimes becomes inaudible, and then it must be felt by a finger or two held close to the mouth of the patient. In order to make this quiet breathing of chloroform anaesthesia audible, some administrators allow the jaw to slip back till there is just sufficient sound made by the soft parts to allow of each respiration being heard. Care, of course, must be taken that the jaw is not allowed to slip too far back.

Some inhalers are now made in which a feather is moved with each expiration of the patient; but these are of less use than would appear at first sight, for the feather is so light that it would be moved by a current of air which would be quite insufficient to maintain the life of a patient.

It is not enough that some movement of the chest and abdomen is observed, for there may be muscular action with very little air passing backwards and forwards ; but for the condition of the patient to be satisfactory each expiration should be heard, or felt by the fingers. When the breathing, which has once been deep and regular, becomes quieter and more shallow, the cause is one of two, viz. that the anaesthesia has been allowed to become either too deep, or too light. If too much of the drug has been administered, the pupil will be found dilated, there will be no corneal reflex, and the pulse will have become worse than it was when the respiration was satisfactory. If, on the other hand, the anaesthesia is too light, the pupil may be found either dilated or very small, as will be explained below, and the corneal reflex will probably be present.

If the respiration during the course of an administration becomes very shallow the lips should be rubbed with a towel, and more of the drug given if the other signs of light anaesthesia are present, while more air must be allowed if it is already too deep. Breathing which becomes more and more shallow, with the corneal reflex present, and the pupil pin-point in size, is generally followed by attempts at vomiting. When ether is being administered it should be remembered that the breathing may become rapid through the stimulating effect of the anaesthetic.

2. Pulse

Though the pulse undergoes many changes during the second stage of the administration, when the third stage is reached it settles down into a regular rhythm, which with ether is accelerated, while with chloroform it is either normal or somewhat slower, the latter condition being frequently noticed in elderly persons. It is unnecessary to keep a finger on the pulse during the whole length

of an administration, but it is important to examine it sufficiently frequently to observe the state of the circulatory system, and to detect the onset of shock induced by the operation.

It is best to keep the same artery under observation throughout the administration; and the facial artery, as it passes over the lower jaw, will generally be found the most convenient, for it may be felt by one of the fingers of the hand which is keeping the jaw in good position.

As the operation proceeds the pulse tends to become smaller and more frequent, especially with the use of chloroform, but this will also happen early in the course of the operation if too much of the drug is given. The other signs will then approach in character those already given in the description of the stage of overdose, and the remedy is obviously to give less of the anaesthetic and more air. The pulse may also become feebler when the operation itself is producing a condition of shock to the patient, when much blood has been lost, and also when the breath is being held in light anaesthesia before the onset of vomiting.

3. The Colour of the Face

The colour of the face is the best indication of the amount of air that the patient is actually receiving.

During the early stages of the administration of ether it is generally slightly more cyanosed than it should be, but, after a few minutes of the third stage, when the patient has been allowed several breaths of air, it should become of a healthy though flushed colour. If this desired end is not obtained, the cause must be sought and remedied. (See Obstruction to Respiration, p. 35.)

During the administration of chloroform it is most important that asphyxia should not be allowed to complicate the depressant influence of the drug, as the danger to

the patient is thereby immensely increased. Hence it is of the utmost importance that the respiration and the colour of the face should be most carefully watched while this drug is being given, and any cyanosis or undue pallor must be at once traced to its cause and remedied.

If the anaesthesia is light, that is, if the corneal reflex is present, the other signs of approaching vomiting will be accompanied by cyanosis, or, if chloroform is being administered, by pallor.

4. Size of the Pupil

When the third stage is first reached, and the corneal reflex disappears, the pupil will generally be found large, especially with ether, on account of the greater limitation of oxygen which necessarily accompanies the induction of anaesthesia by the "closed" method.

Normal Pupil.—When air has been allowed, the pupil becomes smaller, and after about five minutes the average size is reached, namely, a diameter of 4 mm. for ether, and 2·5 mm. for chloroform.

Contracted Pupil.—The size of the pupil during the course of an operation is one of the most delicate indications of the depth of the anaesthesia. If the pupil contracts to what is known as "pin-point," and the corneal reflex is found to be present, unless more of the anaesthetic is given, vomiting will often follow. Of course a very small pupil does not necessarily of itself indicate that vomiting will certainly occur, but it should put the anaesthetist on his guard against allowing the anaesthesia to become too light.

Dilated Pupil.—The pupil will dilate when anaesthesia is allowed to become too deep, or too light. The administrator may be conscious that he has been giving the drug rather freely, the corneal reflex will be quite abolished, and other signs of overdose, as mentioned on p. 15, may be present. To remedy this more air must of course be given.

The pupil will also be large when the patient is suffering from severe haemorrhage, or the shock of a serious operation.

If the dilated pupil is accompanied by a brisk corneal reflex, the cause of the increase in size is the reflex irritation due to the operation. This follows too light an anaesthesia, and the pupil will soon contract when more of the drug is given. This reflex dilatation occurs more readily in the case of children and weakly and anaemic women than it does in men.

When vomiting takes place, a pupil which may have been " pin-point " will often dilate to a large size.

Light Reflex.—When the upper lid is raised the pupil contracts from the influence of light. This reflex is generally obtained quickly during light anaesthesia, but it often becomes slower as anaesthesia deepens, and when the pupil is dilated from an overdose it may be quite abolished, when the pupil is described as " fixed." It is more readily obtained in some patients than in others, and, though it should as a rule be present, its activity is not an exact indication of the depth of the anaesthesia.

5. The Corneal Reflex

This is the movement of closing the eyelids when the sensitive cornea is touched with a finger.

The reflex should not be tested as long as any resistance is felt in the upper lid on attempting to draw it up with a finger. But when this resistance has disappeared the corneal reflex may be tested by touching the cornea with one finger while the upper lid is raised by another.

If there is any movement of either eyelid the reflex is said to be " present," and when there is no movement " abolished."

The testing should always be done carefully, and never when the patient is moving or being moved. When it has to be done frequently during the course of an operation

the eyes should be used alternately, whenever possible, as the cornea becomes less sensitive after much testing.

When the patient has once reached the third stage it will be necessary for the performance of many operations that this depth of anaesthesia should be maintained, in other words, the corneal reflex must be kept away. Of course, the mere presence of the corneal reflex is in itself immaterial to the operator, but when it has reappeared, if more anaesthetic is not given, it may be followed by the other signs of the second stage, namely, swallowing, straining, vomiting, coughing, and muscular movements, and any of these may be sufficient to ruin an important operation.

There are, however, many operations for which the second stage of anaesthesia is sufficient, such as those on the extremities, etc., when a slight movement might be controlled by assistants, and in these the corneal reflex may be allowed to be present, though the other signs of light anaesthesia should, if possible, be kept away. For the performance of serious operations, especially those on the abdomen, it is safer, as a rule, to keep the corneal reflex abolished; but in some emergency operations on the abdomen in very feeble subjects, it is possible to allow the skin incision to be made with the corneal reflex absent, and then allow it to return, as the intestines are less sensitive, and they may often be manipulated without the occurrence of reflex phenomena. But it may often be necessary to deepen the anaesthesia for the suturing of the wound.

In some operations, such as those for the relief of empyema, removal of the thyroid gland, tracheotomy, etc., the corneal reflex should never be lost.

6. Muscular Movements

In most instances the third stage of anaesthesia is characterised by complete absence of muscular movements,

but occasionally, and especially in alcoholic patients, even when the corneal reflex is completely abolished, small movements may be observed. Wrinkling of the brows, and irregular movements of the fingers are the most common. In themselves they are of no moment, but act as a warning to the administrator not to let the anaesthesia become lighter. Besides these, the movements referred to on p. 38 may be noted.

When the anaesthesia is intentionally light, the amount of muscular movement may be used as a rough guide to the amount of anaesthetic to be given ; in other words, the patient may simply be kept quiet, and the movements not allowed to become so extensive as to inconvenience the operator.

In maintaining a patient in a satisfactory condition throughout the course of a long operation, the above signs must always be taken as the guides of the administrator ; and the amount of the drug given, and the air allowed to the patient, will depend not on one alone, but on the sum of all these balanced one against another. Some practice will be necessary before the administrator will be able to recognise at once when he is giving too much, and when too little of any anaesthetic ; but the above-mentioned signs are the only ones that can guide him, and the greater attention he pays to them the sooner will he become proficient in this branch of practice.

Every effort should be made to keep the anaesthesia as " regular " as possible, and to avoid the succession of periods of light anaesthesia in which the patient moves vigorously, followed by periods of anaesthesia so deep that his life may be endangered.

It is well to remember that the objects of the administrator is not to see how much anaesthetic the patient can take with safety, but what is the smallest quantity that

will produce all the results that he requires. On this account, when administering an anaesthetic to an alcoholic man, though the amount of the drug required seems enormous when compared with that which is sufficient for an ordinary individual, yet he must give sufficient to anaesthetise his patient thoroughly, and then as little as will suffice to maintain that depth of anaesthesia which the operator requires.

Recovery from Anaesthesia

After nitrous oxide the return to consciousness is rapid, as the anaesthesia is quickly obtained. The dilated pupils contract, the colour of the face soon becomes normal, or even flushed, and after two or three minutes most patients are perfectly conscious. After-effects are as a rule absent, or if any are present, they are very slight. Some headache or giddiness may be complained of, but a few breaths of fresh air will generally remove these. Vomiting is very rare, unless the patient has just taken a meal, or swallows some of the water with which the mouth should be washed out. As a rule, the patient can walk away feeling perfectly well after five minutes' rest.

After ethyl chloride the recovery is not quite so satisfactory, being slower, and more frequently accompanied by vomiting.

As the anaesthesia from ether and chloroform is more slowly obtained than with nitrous oxide, so the return to consciousness is more gradual.

As the effects of the drug pass off, the corneal reflex, if abolished during the operation, can again be obtained ; the pupils, if dilated from deep anaesthesia, will gradually contract, but if small during the operation may dilate. Should they become very small, or " pin-point," and the face at the same time grow paler, while the breathing is very quiet, or the patient becomes cyanosed through

" holding " of the breath, it is probable that vomiting is about to take place.

The gradual diminution in the depth and rate of the respiration is one of the most noticeable of the symptoms of the recovery from ether.

To describe thoroughly the return to consciousness all the signs of the first and second stages of anaesthesia might be enumerated, as the patient must pass through these in the reverse order to that in which they occurred during the induction.

The care of the Patient after an Anaesthetic

When the operation is finished, the dressings applied, and the patient's wet clothes are removed, he should be lifted into the bed, which should have been previously warmed by hot-water bottles. Care should be taken that there is no jerking of the patient, but that he is gradually lifted from the table to the bed, while the body is maintained in a horizontal position, and laid, not dropped, on to the bed. During the transfer the anaesthetist should take charge of the head, and see that respiration continues satisfactorily. Undue shaking or jerking of the patient at this time will encourage vomiting, while if the head is suddenly elevated, syncope may occur. For this reason, when it is necessary for the patient to be carried upstairs on a stretcher, it is better that he should be taken with his feet first.

The temperature of the room in which the patient is placed after the operation should be kept about 65°, and though ventilation should be free, he must not be exposed to a draught, especially after the administration of ether.

If the nature of the operation allows it, the best position for the patient will be almost on one side, with a pillow under the uppermost shoulder. If there is nothing in the operation to indicate to which side the patient should be

turned, the one which is most convenient for the purposes of nursing should be chosen. When lying on one side respiration is often more easy, vomiting is less likely to occur, and if it does, it can be more satisfactorily treated ; coughing also will be more easy.

The room should be darkened, and if the patient has come round sufficiently to understand what is said to him, he should be told to go to sleep. Talking with a patient in this stage is to be discouraged, as vomiting is more likely to occur if it is allowed, and absolute quiet in the room is desirable. No friends should be allowed in the room till consciousness has completely returned, and even then strict quiet must be insisted on.

During the recovery from an anaesthetic all patients should be carefully watched. Vomiting is very liable to occur, and if the patient is neglected, some of the vomited matter may be sucked back into the larynx, and give rise to very serious symptoms.

The patient must be kept warm by means of hot-water bottles and blankets, and if in spite of these the nose and the extremities remain cold to the touch, more active measures must be taken. (See treatment of Shock, p. 29.) Great care must be taken that hot-water bottles are not allowed to come in contact with the patient, as extensive burns have been caused in this way.

The anaesthetist should not leave a patient till he has been placed in bed, and he considers that the pulse and respiration are satisfactory, and improving in quality.

Should a patient be excitable or noisy on recovering consciousness, little should be done to restrain him at first, but persuasion should be tried, and care taken that in any violent movements to throw off the bed-clothes he does not become unduly exposed to cold. Should the condition become worse instead of better, a hypodermic injection of morphia should be given, and the patient

restrained by assistants from doing violence to himself or his surroundings. On no account must a patient's action be controlled by tying him down to the bed, but he may be restrained by hand till the morphia has had time to take effect.

Extreme excitement during the recovery from an anaesthetic is generally only observed in alcoholic patients.

Vomiting

If ether has been the anaesthetic employed, vomiting as a rule takes place early in the stage of recovery, often so early that the patient is not conscious of it, and does not remember it afterwards. The vomit consists chiefly of saliva that has been swallowed during the early stages of the administration, with the mucus that has been hanging about the pharynx, and may be mixed with a little bile-stained fluid from the stomach. If the patient has been well prepared for the operation, no sign of food will be noticed in the vomited matter. After this removal of saliva and mucus the patient will as a rule breathe more freely, the colour will improve, and there will often be no further trouble, save a little headache, and a more or less distinct sensation of the smell and taste of ether.

After chloroform vomiting occurs in fewer cases ; but when it does, it is later in the stage of recovery, often when the patient is quite conscious. It is then very annoying, and will be distinctly remembered by the patient. Vomiting after chloroform is sometimes very severe, being both frequent and accompanied by severe straining, and in some patients by a marked tendency to syncope.

Treatment.—For slight cases no treatment beyond abstinence from all foods for three or four hours is necessary. Small pieces of ice are frequently given to be sucked, but teaspoonfuls of water as hot as the patient can take it,

given at intervals of about a quarter of an hour, will generally be of more service in checking the vomiting. With this hot water a minim of the tincture of Nux Vomica may be given. If the water can be taken really hot, it is best given in a china spoon, as a metal one may burn the lips.

Should the vomiting not yield to these remedies, ten grains of bicarbonate of soda may be given in a cup of hot tea or coffee. Should these fail, the patient must be treated on the same lines as one suffering from persistent vomiting from other causes. Ice-bags, and a mustard leaf to the epigastrium have been recommended, and occasionally the stomach has been washed out with a good result. The inhalation of toilet vinegar sprinkled on a handkerchief, and held near the patient's face, has sometimes proved of service in checking vomiting.

Thirst

This symptom is best treated by teaspoonfuls of hot water given as above, or by copious enemata of hot water. The taste of ether, which annoys some patients on their recovery, may be lessened by sucking peppermints or a small piece of lemon; while if dryness of the tongue is complained of, the mouth may be swabbed out with glycerine and borax.

Shock

At the end of a long and serious operation the patient may be found blanched, with the extremities and nose cold to the touch, a cold sweat on the forehead, the eyelids slightly apart, the pupils fixed and dilated, the respiration shallow and perhaps sighing in character, and the pulse rapid, and small in volume.

Such a patient is suffering from severe surgical shock. The anaesthetic may have been given too freely, but the

loss of blood and the shock of the operation are generally the principal causes.

Treatment.—A patient in this condition requires very careful management and nursing to enable him to recover. He must be placed carefully in bed as soon as possible, and extra warmth supplied in the form of hot-water bottles. The legs of the bed at the lower end should be raised and supported, so that the head is dependent, and not more than one pillow should be used. The lips are then to be briskly rubbed with a towel, and brandy may be rubbed on them, and on the inside of the cheeks. Strong " smelling salts," or Liquor Ammoniae should be held near the nostril. All these manoeuvres encourage respiration.

Two or three drachms of brandy may be given hypodermically, or an ounce of brandy mixed with two ounces of hot water, or, if it is ready, the same quantity of hot coffee, should be given by the rectum. Strychnine may be given hypodermically in a dose of one-thirtieth of a grain, and the injection of fifteen minims of the Inj. Ergotae Hypoderm. (B.P.) has been strongly recommended.

If this condition is caused by an excessive loss of blood, the injection of a pint of hot saline solution into the rectum should be tried, and if this fails, saline fluid should be infused into a vein, and some solution of adrenalin in the proportion of a drachm to the pint may be added with advantage. Artificial respiration may sometimes be required.

Bronchitis and Broncho-pneumonia

Bronchitis is supposed to be a frequent sequel to the administration of an anaesthetic, especially of ether, but this frequency has been much exaggerated, and, in private practice at least, it is not common. It occurs more frequently in hospital patients, and this suggests that it is not so much the ether that is to be blamed as the exposure of the patient after the operation.

He is taken from a theatre which is often over-heated, wheeled out into a draughty corridor, through several wards and passages, perhaps up or down in a lift, and finally reaches his bed. The temperature of the ward is probably much lower than that of the theatre which he has just left, and he may be placed near an open window which is providing the ventilation for the ward. The wonder is that this exposure does not produce more cases of bronchitis among hospital patients. In this connection it is interesting to note that bronchitis, and even broncho-pneumonia have followed operations performed under spinal analgesia.

Of course if ether is given for some time to a patient already suffering from bronchitis, one must expect the symptoms to be increased by it; but if the lungs are healthy to start with, and there is no undue exposure to cold after the operation, bronchitis will be a rare sequel to the administration of ether. The patients most likely to be troubled by this complication are those who suffer from a cough in the winter, or who have a family history of phthisis or other lung affection.

The operations after which it is most likely to occur are (1) abdominal operations, when the patient must lie flat on his back after the operation, and the abdominal respiration is impeded by the discomfort of the wound, and the pressure of the dressings; and (2) amputation of the breast, when during the operation the chest is much exposed, and afterwards on account of the tight bandaging it is difficult for the patient to cough, and so get rid of any mucus that may accumulate in the bronchi.

In all these cases it is better that ether should not be given for long, but if anaesthesia has been induced with it, and the operation is likely to be prolonged, a change should be made to the A.C.E. mixture or chloroform at the end of half an hour or so.

A septic form of bronchitis and broncho-pneumonia may occur after operations in the mouth, especially after removal of the tongue. It is due to the inhalation of septic material from the mouth, and the risk of its occurring should be diminished by careful cleansing of the mouth, and especially the teeth, for some days before the operation.

Treatment.—Should any cough be noticed after the patient has recovered consciousness, special care must be taken to keep him warm in bed, and out of any draught.

There is nothing in the bronchitis or broncho-pneumonia which may follow an anaesthetic which calls for treatment differing from the routine treatment of bronchitis, but the patient should be placed in such a position that he is able to expectorate ; that is to say, if from the nature of the operation it is undesirable that he should sit up, he must be at least turned to one side, and supported there by pillows.

Food after an Anaesthetic

The longer a patient can go without food after the recovery from an anaesthetic, the less likely he is to be sick when he does take it. The first food should be entirely liquid, and tea is probably the best of all. If the patient does not wish for tea, coffee or a little soup may be given instead, but none of these should be given for at least two or three hours after the operation. After an abdominal operation, or one after which it is important that the patient should be kept especially quiet and free from vomiting, food may be withheld from the mouth for a much longer time, and the patient fed by the rectum.

If the patient take the liquid food without any nausea or vomiting following it, some more solid food may be given two hours afterwards. In the choice of this the patient may be consulted, and bread and milk, or even fish, may be allowed.

Rare Sequelae of Anaesthesia

Under this heading may be noted :

Insanity

This, as a rule, only occurs in a patient who has previously been insane, and has recovered for a time. It may take the form of acute mania, or melancholia.

Patients who are insane take anaesthetics well, and are not as a rule made worse by them ; but if ever it comes to the knowledge of the anaesthetist that a patient has at some time or other been insane, it is his duty to warn the friends that it is quite possible that, though the administration may be perfectly successful, yet, on the return of the patient to consciousness, some of the old symptoms of insanity may again be manifest.

Paralyses

These are (*a*) central, and (*b*) peripheral. The *central* paralyses are generally the result of a cerebral haemorrhage, and occur in old people, or those with very degenerate arteries. They may be due to the struggling which takes place when a nervous patient is being anaesthetised, but it has happened on more than one occasion that a haemorrhage has occurred just before the administration has been commenced, and the anaesthetic in consequence has escaped the blame which otherwise would have laid at its door. In a very neurotic subject an anaesthetic may be the starting point of some functional nervous disorder.

The *peripheral* forms are local paralyses, generally of the muscles of the arm and shoulder, from some faulty position in which the arms are kept above the head during the operation, or from pressure of some part of the arm against the edge of the table during a lengthy operation. Such paralyses are to be treated on general principles, and for

further information an article on "Post-Anaesthetic Paralysis," by Turney, in the *Transactions of the Society of Anaesthetists*, Vol. 2, should be consulted.

Albuminuria in a patient whose urine was previously normal is said to be more common after chloroform than after ether; but if albuminuria already exists, it is more likely to be increased in severity after a prolonged administration of ether, than after one of chloroform.

Glycosuria has followed the inhalation of chloroform.

"**Delayed Chloroform Poisoning**" is described on p. 165.

CHAPTER II

DIFFICULTIES AND DANGERS OF ANAESTHESIA

DANGER to the life of a patient inhaling an anaesthetic may arise in connection with one of the two great systems of the respiration and the circulation. Though one system may be affected primarily, the other soon becomes involved; and in many cases when the condition of a patient on the operating table becomes serious, it is hard to tell which was the first to fail.

FAILURE OF RESPIRATION

The causes of the failure of respiration may be described under two heads. (1) The mechanical, or local, producing obstructed breathing, and (2) the central, or general causes of failure.

(1) Obstructed Breathing

This may arise (*a*) in the *mouth*.—In the old and edentulous the lips may so fall together during inspiration that they form a sort of valve, and prevent the free entry of air.

The tongue may cause obstruction from its large natural size, or because of its increased size from congestion, and, if the head is not kept in a suitable position, will fall back against the pharyngeal wall, and almost completely block the air-way. Further back, large tonsils and collections of adenoid growths, inflammatory swelling due to cellulitis of the neck, etc., or retro-pharyngeal abscess, are the

commonest causes of obstruction, together with foreign bodies, as plates of artificial teeth, food, vomited matter, or blood.

(*b*) In the *nose*.—Polypi, spurs, malformations of the septum, swelling of the mucous membrane of the turbinate bones, and tumours, will block the nasal air channel; and, if the mouth is kept tightly closed, the air-way will become completely obstructed. It must be remembered that many of the causes which beforehand only narrow the air-way, may, on account of the congestion produced by the anaesthetic, completely obstruct the breathing; and this will be noticed more frequently when ether is given.

(*c*) In the *larynx, trachea, and bronchi*.—Here the obstruction to respiration is generally due to the presence of foreign bodies, such as plates of artificial teeth, food, blood, or other fluid, either from the mouth, or coughed up from the chest, or vomited from the stomach, and sucked back into the air-passages by an inspiration. Lister has pointed out that the aryteno-epiglottidean folds, which are normally well supplied with blood, may become so congested that when they fall together like a curtain and touch the base of the epiglottis, they will produce complete obstruction. Excessive secretion of mucus in the air-passages may produce some considerable obstruction, as will oedema of the lungs.

Under this heading must be specially mentioned **Spasm of the Glottis**. In this condition the air-way is more or less occluded by the closure of the superior aperture of the larynx through muscular action. It may occur with ether or chloroform, and during light or profound anaesthesia. It may be distinguished from the other causes of obstructed respiration by the curious "crowing" inspirations which accompany it, and which often become higher in pitch as the air-way becomes more occluded. The vibrations

producing the sound may also be appreciated by fingers placed over the larynx.

The *causes* of spasm of the glottis may be divided into local and remote.

(1) *Local causes.*—The first of these is the irritating nature of the anaesthetic which is being inspired, and is generally the result of the drug being administered from the first in an insufficiently dilute form.

The next cause is the presence of a foreign body in the larynx. This need not be so large as to produce obstruction by its mechanical action as described in the first part under this heading ; but a small foreign body will cause enough irritation to produce the muscular action which closes the glottis. The most usual forms of foreign body which find their way into the larynx are teeth, or fragments of teeth, which fall there during extraction, or, having been left in the mouth, are sucked in by the first vigorous inspiration, fragments of broken instruments, and vomited matter sucked back from the pharynx.

(2) *Remote causes.*—Under this heading the reflex muscular action which closes the glottis receives its stimulus not from the sensitive mucous membrane of the organ itself, but from some remote part of the body. This form of spasm will be met with most frequently in operations upon sensitive parts, especially the genital organs.

(*d*) Respiration may be mechanically obstructed by causes which hinder the proper working of the *chest*, such as corsets, tight bandaging, a faulty position of the patient on the operating table, assistants leaning on the chest, or by the distension of the pleural cavities with fluid.

(*e*) Causes which hinder the proper action of the diaphragm will also mechanically affect respiration such as a large tumour, tympanites, or much free fluid in the *abdomen*.

Signs of Obstructed Breathing

The onset of the symptoms will be sudden or gradual, as the cause is complete or partial. Respiration will become more noisy, and the stream of air passing backwards and forwards will diminish. If the obstruction is severe the colour of the face will change to some shade of blue, or sometimes almost black. The pulse will not be altered at once, but if the obstruction is not removed it too will fail. The movements of respiration may still be seen in the chest and abdomen, though very little air may be passing ; and clonic movements of the arms, similar to the jactitations seen in connection with nitrous oxide anaesthesia, may sometimes be noticed. If the obstruction is not removed the respirations will become more and more feeble, and then cease.

(2) Failure of Respiration from Central, or General Causes

Respiration may fail with the circulation as a part of the gradual death of a patient from shock, loss of blood, or an overdose of the anaesthetic, and this failure will be more gradual than that caused by obstruction. The breathing may also suddenly stop when an incision is made or the operation otherwise begun before the patient is well under the influence of the anaesthetic—this may be described as reflex failure of respiration during light anaesthesia.

In some operations on the deeper structures of the neck, when the large vessels and nerves are being manipulated, the breathing may suddenly stop even before any change has been detected in the pulse. This has been attributed to irritation of the vagus, others have considered it due

to excitation of the sympathetic nerves, but the exact physiological explanation is not obvious.

By far the commonest form of temporary failure of the respiration is the holding of the breath which occurs in connection with the act of vomiting. This is an accompaniment of light anaesthesia, and when it occurs the corneal reflex will almost certainly be present.

An inclination to vomit may sometimes be noticed near the beginning of the administration, and then it is generally in a very nervous patient, or in one who has not been properly prepared. It may occur at any time during the course of an operation if the anaesthesia has not been kept sufficiently deep, but it is most commonly seen after the anaesthetic has been withdrawn and the patient is returning to consciousness.

Before the breath is actually held it may have been noticed that the respiration has become more shallow, the pupil being at the same time small, with the corneal reflex as a rule present. If the breath is held in this way for some time the ordinary signs of asphyxia will show themselves; the face will become cyanosed, the circulation affected, and the pulse smaller, and the pupils may then dilate.

The condition of the patient will generally improve rapidly if more of the anaesthetic is given, or after the act of vomiting.

Treatment of Respiratory Failure

The first thing to be done is to see if any obstruction to the breathing can be found, and then removed. If the trouble is caused by the valve-like action of the lips, they may be kept separated by inserting a finger between them, or by placing a dental prop between the teeth or gums.

If the teeth of the lower jaw become locked behind those of the upper, and so prevent the lower jaw being pushed

forward, the jaw should be depressed, and then pushed forward till the lower teeth are in front of the upper, and they should be maintained in this position.

It is most important that the tongue should be prevented from blocking the air-way by falling back against the posterior wall of the pharynx. Unless the position would be unfavourable to the operator, the head should first be turned over well to the right side, for the tongue will then tend to fall into the right cheek rather than backwards into the pharynx. Pressure should now be exerted by one of the fingers of the left hand placed behind the angle of the jaw, and pressing directly forwards, *i.e.* towards the mouth. It is a common mistake for the beginner not to place his finger behind the angle, but on some spot on the lower border of the jaw; in this way pressure will have much less effect. Much help can be given in keeping the jaw in a good position by means of some of the fingers of the right hand placed under the chin. This can be done as shown on p. 124, without affecting the holding of the inhaler. If this is not sufficient, pressure may be applied behind the angle of the jaw which is undermost.

If the patient has a delicate skin, and if the pressure behind the jaw has to be kept up for a long time, it is as well to have a fold of a towel between the finger and the skin, as there will then be less risk of bruising.

When consciousness is first lost considerable force is sometimes required in the case of young adult males to keep the jaw in a favourable position, but fortunately as the operation proceeds less is required. It is important while keeping the jaw forward to make sure that the tongue is not caught between the teeth. This sometimes happens during the administration of ether, when the patient has been struggling, and the inhaler has been kept on the face without being removed for some little time. If the jaw does not move forward easily when pressure is first exercised

behind the angle, the anaesthetist should always look into the mouth to see if it is prevented from advancing by locking of the teeth, or by the tongue being caught between them.

When a patient is in the Trendelenburg position the tongue may swell and obstruct respiration. To remedy this condition Hewitt has designed an " artificial air-way." This consists of a rubber tube, half-inch in diameter and three inches long, attached at one end to a circular metal ring and at the free end cut obliquely.

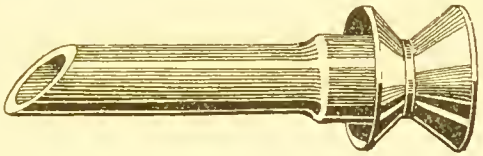

Fig. 4.—Hewitt's Artificial Air-way. Half the natural size

The teeth, or gums, should hold the metal ring, while the free end is in position opposite the laryngeal orifice. This simple device is often of much service.

Should a favourable position of the lower jaw not improve the respiration, the mouth must be opened and the tongue drawn forward. If the teeth are firmly clenched they will have to be separated before a gag can be inserted, and this should be done with the wooden wedge. Metal wedges are sometimes used, but require more care in their application, lest the teeth be injured. As soon as sufficient room has been made by the wedge, the gag should be inserted, care being taken that it does not dislodge any teeth. The mouth should now be opened sufficiently wide, all mucus, etc., should be sponged out, and the tongue drawn forward by the tongue-forceps. Lister insists that this drawing forward of the tongue acts in a reflex manner, especially in separating the soft parts above the glottis which may have fallen together, and is not simply a removal of the

mechanical obstruction of the base of the tongue from the air-way. The forceps should be closed sufficiently to hold the tongue firmly, and no more ; and as soon as their aid can be dispensed with they should be removed. Through careless handling with forceps the tongue is often considerably bruised, and in consequence very sore for some days afterwards. Instead of the special tongue-forceps a pair of artery forceps is occasionally used in an emergency ; but it should be remembered that though they are very effective, they are more likely to damage the tongue, as they exert much more pressure, and therefore they should be removed as soon as possible. If the tongue has to be kept forward artificially for some time, especially if part of it is being excised, it will be less damaged and much less painful to the patient on recovery if, instead of using the forceps, a ligature is passed through it, and it is kept forward by means of this.

When both nostrils are more or less obstructed, and the mouth, as is usually the case, is kept almost closed, there is very little room for the necessary current of air to pass for the maintenance of respiration. This is specially noticeable in the case of patients suffering from post-nasal growths and enlarged tonsils. In these patients it is as well to make sure that there is at least a sufficient air-way through the mouth by keeping it open with a dental prop placed between the teeth. This may be kept in position throughout the operation, and is more convenient than a gag, which is sometimes used, as it will not prevent the application of the inhaler, and the arrangement of the head in any particular position will not be interfered with by the arms of the gag getting caught in the pillow. The gag shown on p. 191 possesses a great advantage over most forms, as it can be kept in position while a face-piece is applied over it.

If the breath is being held, and no obstruction can be

discovered, the lips should be rubbed briskly with a towel, and this simple measure will often start the breathing again, or ammonia may be held to the nostrils. The corneal reflex should be tried, and if present the anaesthetic should be given more freely, but if it is absent, more air should be allowed. This treatment must be tried in cases of **Spasm of the Glottis** when it is not caused by a foreign body in the larynx ; but this form of obstructed breathing is not easily overcome. It may remain unrelieved with a very light anaesthesia, or even when the anaesthetic is pushed to the limits of safety, and the pupils become dilated from the overdose. If ether is being given the spasm may disappear if a change is made to chloroform ; but its real cause is not thoroughly understood, and certainly in some cases is very difficult to remedy, especially when the operation is upon one of the very sensitive parts, as the genital organs.

Spasm due to a foreign body in the larynx occurs in dental practice more frequently than in surgical operations. The body of the patient should be bent forwards in the chair, and the back should be slapped vigorously. Coughing is to be encouraged, as by this means the foreign body is often removed. An attempt may be made to feel for the cause of irritation, and if found, to remove it with the finger or forceps. Inversion has been recommended, but this should not be done till preparations have been made for laryngotomy, as if the foreign body has passed through into the trachea, it may again enter the larynx when the patient is inverted. When the breathing is seriously obstructed, and the patient becomes cyanosed, laryngotomy should be performed immediately.

If the accident happen at a dentist's this operation will in all probability fall to the anaesthetist, and for this reason he should never administer any anaesthetic without having the necessary instruments at hand ; but, if a surgeon is operating, he will perform the laryngotomy.

If the obstruction to the breathing seems to be due to the accumulation of mucus in the air passages, the mouth should be opened, and the pharynx cleared out with a sponge on a holder, and the anaesthetic changed from ether to chloroform or A.C.E.

If there still seem to be some obstruction from accumulated mucus which cannot be removed by a sponge, the patient may, with the consent of the operator, be allowed to come round a little, till the mucus is removed by the coughing or vomiting, and then the pharynx should again be sponged out. The patient, if possible, should be turned on to his side till the breathing becomes relieved, and then the administration may be continued with chloroform or A.C.E. When mucus has been secreted in large quantities, the patient should be carefully watched for any sign of bronchitis, and treated accordingly.

Pressure on the chest, whether from tight clothing or from assistants leaning on the patient, must be removed as soon as discovered. When respiration is hampered by the presence of fluid in the pleura or abdomen, the anaesthesia should be as light as possible till the fluid or tumour is removed, and the breathing is free. When the breath is held as the first incision is made the anaesthesia is probably too light, and respiration will soon become regular if the anaesthetic is given more freely.

If rubbing the lips does not start respiration, **rhythmic traction of the tongue** may be tried. To do this the tip of the tongue is seized with forceps, and the tongue gently pulled forward out of the mouth and then allowed to return. This movement may be repeated about twenty times or more a minute, and is frequently useful in restoring respiration: it may also be tried while artificial respiration is being performed. The success of this treatment seems to depend on the reflex action produced by pulling the tongue forward.

If these means fail, and no obstruction can be found, artificial respiration must be performed. The anaesthetic must be completely withheld, and it must be ascertained that there is a clear air-way, or any attempts at artificial respiration would be useless.

If the larynx is blocked and cannot be cleared, tracheotomy or laryngotomy must first be performed. Occasionally the obstruction is below the larynx, as when a tumour or an enlarged thyroid gland presses on the trachea, and in this case tracheotomy might become impossible or useless, and intubation would then give the only chance of making an air-way.

Artificial Respiration

The simplest way of aiding respiration artificially is to compress the thorax during expiration, and in some

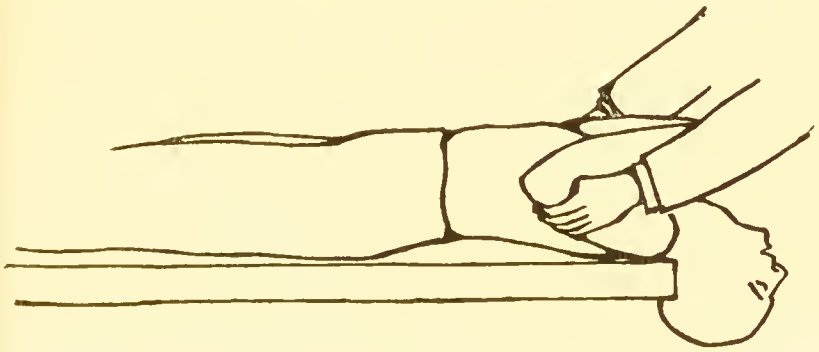

FIG. 5.—ARTIFICIAL RESPIRATION BY SYLVESTER'S METHOD. EXPIRATION

cases this is sufficient; but when respiration is almost imperceptible, or has actually ceased, more vigorous methods must be adopted.

There are several methods of performing artificial respiration.

Sylvester's Method.—The patient should be lying flat on his back on the operating table, with the head lower than

the rest of the body, the mouth opened with a gag, and the tongue drawn forward by forceps. The tongue-forceps should be held by an assistant, while the anaesthetist should perform the artificial movements. The patient's arms are to be seized, one in each hand, about the elbow, and are then to be firmly compressed against the walls of the thorax (Fig. 5). If there is any attempt at natural respiration, however feeble it may be, this compression of the thorax must be timed with expiration. If there is none, expiration should be performed before inspiration, so that any anaesthetic present in the air-passages may be driven out, rather than any fresh dose should be sucked in by forced inspiration.

Fig. 6.—Artificial Respiration by Sylvester's Method. Inspiration

After the arms have been firmly compressed against the chest, they should be gradually lifted away in a direction upwards and outwards, making as wide a sweep as possible, till they meet above the patient's head (Fig. 6). After a short pause in this position they are again to be brought down and the chest firmly compressed as before. The movements should be repeated about sixteen times a minute, and their efficacy depends much more on the care with which each is performed, than on the number of times it is repeated. The value of this artificial respiration will be much increased if, when the arms are being pressed against the chest-wall, an assistant should also compress the abdomen firmly, as though trying to drive the abdominal

contents against the diaphragm. If enough assistants are available, rhythmic traction of the tongue may be employed at the same time.

Care should be taken in bringing the arms above the head that they are not injured by pressure against the edge of the table ; this is more likely to happen if the head is hanging over.

Howard's Method.—In this method the patient's arms are raised above the head, and tied together. The shoulders are raised on pillows, and the head is extended. The operator then kneels astride the patient, and places his thumbs on the xiphoid cartilage, and spreads his fingers along the lower costal margin. He then leans forward, and with his whole weight suddenly and firmly presses upwards and inwards against the diaphragm. This pressure is maintained for two or three seconds, and is relaxed by the operator suddenly raising himself. It should not be repeated more than sixteen times a minute.

This method of artificial respiration is particularly useful in the case of old people whose chest-walls are rigid. It may be combined with Sylvester's Method.

Schäfer's Method.—The patient is placed face downwards, and the movements are thus described by Schäfer:

" To effect artificial respiration, place yourself athwart or on one side of the patient's body in a kneeling posture—and facing his head. Place your hands flat over the lower part of the back (on the lowest ribs), one on each side, and gradually throw the weight of your body forward on to them so as to produce firm pressure—which must not be violent—upon the patient's chest. By this means the air (and water, if there is any) is driven out of the patient's lungs. Immediately thereafter raise your body slowly, so as to remove the pressure, but leaving your hands in position. Repeat this forward and backward movement (pressure and relaxation of pressure) every four or five

seconds. In other words, sway your body slowly forwards and backwards upon your arms twelve to fifteen times a minute, without any marked pause between the movements."

It has been shown experimentally that this is a very good method of artificial respiration. It is obviously unsuited for patients undergoing an abdominal operation, but it might be of special service in removing fluid vomit, blood, or pus, which has entered the air-passages.

Some authors strongly advise **inflation**, that is the actual distension of the lungs with air by means of bellows and a tube passed through the mouth or nose, while others have recommended inflation with oxygen. In whichever way the artificial respiration is performed, it is most important that it should be carried out deliberately, and without hurry. Patience is also necessary, for natural respiration has been restored after being absent for more than an hour. If **oxygen** is at hand, it may be administered during artificial respiration.

If respiration fails in infants or young children, they are best treated by **inversion.** Both feet should be seized in one hand, and the child held up by them, the head just resting on the operating table ; and one finger of the other hand should be placed in the child's mouth to keep the tongue well forward. While in this position an assistant should compress the chest rhythmically. As stated above, if there is any attempt at natural respiration, the chest should only be compressed during expiration.

In slight cases of respiratory failure much may be done by rhythmical pressure on the abdomen during expiration. It is specially useful in children. Other means of restoring natural respiration have been suggested which, though they may help in minor cases of failure, are not likely to be of much service in the more serious ones. They are, flipping the chest with cloths alternately hot and cold,

applying alternately hot and cold sponges to the perineum, holding strong ammonia to the nose, etc.

The drug which is of most use in stimulating respiration is **Strychnine.** It should be given hypodermically in doses of from 3 to 5 minims of the Liquor Strychninae Hydrochloratis, 3 minims containing about $\frac{1}{32}$ grain of the drug. This dose may be repeated if it seems necessary, but the artificial movements must on no account be relaxed.

Failure of the Circulation

Failure of the circulation may occur suddenly, when it is spoken of as syncope, or it may come gradually, towards the end of a long and serious operation. These two varieties will be shortly considered separately.

Sudden Failure of the Circulation—Cardiac Syncope

Syncope is the gravest danger which threatens a patient who is about to take an anaesthetic. It is almost unknown with nitrous oxide, is rare with ether, but unfortunately is more common with chloroform and its mixtures. It is a cause of death not only in the weakly, but in the robust adult male, and often the operation to be performed has been quite trivial. Many deaths have followed the administration of chloroform to a patient sitting upright in a chair, for the extraction of one or two teeth, a practice which cannot be too strongly condemned. Syncope may occur through fear during the early stage of induction, and patients have occasionally been known to die before any anaesthetic has been dropped on the mask. It may be remembered that when chloroform was to have been administered for the first time in public, Simpson was delayed, and the surgeon decided to operate without anaesthesia, but the patient died as the first incision was made.

Syncope may occur in a slight degree if an operation is begun before the patient is sufficiently anaesthetised,

and the pulse may not be felt for a few seconds after the first incision has been made. It may be noticed also when a patient is recovering consciousness, when the breath is held before the act of vomiting, or when a patient is suddenly moved into a new position, and especially when the head is suddenly raised.

Even when the patient is fully anaesthetised, that is to say when the corneal reflex is abolished, it may occur during certain operations when much shock is caused, such as during manipulation of the deep parts of the neck, on pulling the kidney out on to the loin, during the enucleation of the prostate, etc.

A serious degree of cardiac syncope may arise when air enters a vein.

But the most startling, and most fatal form of syncope, and the one in which treatment is of least avail, is that caused by an overdose of chloroform.

Death from an Overdose of Chloroform.—More has been written on this point than on any other connected with the subject of anaesthesia, and the opinions of writers are widely divergent. Most are agreed that that death is caused by heart failure, though the two Hyderabad Commissions deny that primary syncope ever occurs.

Leonard Hill considers that death is due to the direct effect of the chloroform on the heart muscle, and says:

"Concentrated vapour of chloroform is presented to the respiratory orifice, the nerve endings of the sensory fibres of the vagus in the respiratory tract are powerfully excited. The animal struggles, the glottis is closed, and by the violent contraction of muscles the intra-thoracic pressure is raised. The effect of raising the intra-thoracic pressure is to diminish the output from the right heart, to congest the venous system, and lower the arterial tension. The lungs are also compressed, and to a great extent emptied of blood. Blood supply to the coronary arteries is

diminished; this is due to the fall of arterial tension. The oxygen in the blood is decreased owing to the prolonged holding of the breath. By these means the nutrition of the heart is impaired. Finally, owing to the excitation of the respiratory centres caused by the asphyxial blood, the animal is forced to take two or three deep inspirations. The lungs are immediately surcharged with chloroform vapour, and the blood reaches the coronary arteries carrying a dose of chloroform sufficient to throw the heart into paralytic dilatation."

Embley, who has done some of the best of the recent work on the subject, considers that the heart failure is principally caused by vagus inhibition, and has emphasised the effect of atropine in lessening the excitability of the nerve. With this object some administrators inject atropine hypodermically before giving chloroform. Space will not permit of an adequate discussion of this important subject.

Signs of Cardiac Syncope

In the severe forms of syncope the signs are unmistakable, and most startling in their onset. With no warning, the patient suddenly becomes blanched, the circulation and respiration fail, if not together, with no appreciable interval between them, the eyelids are separated, the pupils widely dilated, and corneal reflex absent—in fact, the patient is to all appearances dead.

This is the form which occurs during the early stages of the administration of chloroform, and from which it is so hard to recover the patient.

In the milder forms of syncope there is more often some warning. The patient becomes pale, the pulse gradually fails, and the pupils slowly dilate. Respiration is hardly affected at first, but gradually fails with the circulation. This form is generally met with in cases of syncope arising

during light anaesthesia, which may be described as reflex ; and also when vomiting is accompanied by syncope. From this form there is fortunately much more hope of recovering the patient.

Treatment of Cardiac Syncope

The most important treatment of cardiac syncope is *preventive ;* in fact, in the severe cases, remedial treatment is often of no avail.

When a patient is suffering from cardiac disease, or has on some previous occasion exhibited alarming symptoms while under an anaesthetic, special attention should be given to the preparation (p. 3), the choice of the anaesthetic (p. 179), and its administration.

The anaesthetic should be given very gradually, and respiration must be carefully watched. It is not enough to see that some movement is taking place in the chest or abdomen, but each inspiration and expiration should be heard or felt by the anaesthetist. If the breath is held, the lips should be briskly rubbed with a towel or cloth, and no fresh chloroform should be poured on the mask till the respiration starts again. When the breath is held for a prolonged period, as in the struggling stage, special care must be taken when the patient takes his first inspiration, which must of necessity be a deep one, that he has a free supply of air. This is the most dangerous time for the patient in the hands of an unskilled anaesthetist. While the breath is held, more and more chloroform may have been poured on to the mask, and when the patient does at last breathe, the dose of chloroform that he takes with his first inspiration will be a poisonous one, and the syncope which follows will often prove fatal.

Care must be taken that the air-way is perfectly clear, for any accompanying obstruction to respiration will make the prognosis infinitely more grave.

Remedial Treatment.—The anaesthetic must, of course, be entirely withheld until the patient is in a perfectly satisfactory condition.

The head should be lowered, and, while an assistant opens the mouth with a gag and holds the tongue forward with forceps, the anaesthetist should perform artificial respiration.

Artificial respiration is the most efficient means we possess for the recovery of a patient in a state of syncope, and this should be carried out in the way described on p. 45. Strychnine, too, may be given hypodermically, and rhythmic traction of the tongue will also be of service.

If oxygen is at hand it may be administered with the artificial respiration.

Besides these measures, there are others more specially directed to the circulatory system, and they should be tried. The heart may be helped to contract by actual compression with the hand. This should be tried during the artificial expiration, a hand being passed as far as possible under the left costal margin, and an attempt made to compress the heart with it.

As a last resource an abdominal incision may be made, and the heart massaged through the diaphragm. Manual compression of the heart has probably saved a patient when circulation had failed through the entry of air into a vein, and several other instances of its efficacy have been recorded.

Hot cloths may be applied to the praecordium, and the heart itself may be stimulated by means of an electric current, or even by acupuncture, that is the introduction of a needle into its cavity; but this is of very doubtful value, and electric stimulation may inhibit the heart rather than cause it to contract, and thus be more harmful than beneficial.

Brandy in doses of three or four drachms may be given

hypodermically. An ounce may be given in an enema of a pint of hot water. The inhalation of Nitrite of Amyl has been recommended, and a capsule may be broken and held to the patient's nose while artificial respiration is being carried on, or a few drops of the strong Liquor Ammoniæ may be used in the same way.

Gradual Failure of the Circulation

The causes of gradual failure of the circulation are :

(1) Shock, from a very long operation, or from one on important organs, such as the abdominal viscera, or the brain.

(2) Loss of blood during the operation.

(3) A gradual overdose of the anaesthetic.

Two or more of these causes may be combined, and when, in addition, there is some obstruction to respiration, which prevents the proper oxygenation of the blood, the symptoms will be proportionately more marked.

Life is endangered through an insufficient supply of blood to the respiratory centre.

Signs of Gradual Failure.—In this form of circulatory failure there will generally be sufficient warning. The patient's face gradually becomes pale and blanched, the eyelids remain apart, the pupils slowly dilate, the nose and forehead gradually become colder to the touch, sweat forms on the forehead, the pulse becomes smaller, more frequent, perhaps " running " in character, and finally imperceptible at the wrist, and respiration fails with the circulation.

Treatment.—When the pulse is found to be deteriorating, and becoming faster and faster, treatment is called for.

The administrator should first satisfy himself that there is no obstruction to respiration. If the anaesthesia seems to be too light, and there is a tendency to vomit, the anaesthetic should be given rather more freely. If, however,

the anaesthesia is profound, as shown by the absence of the corneal reflex, etc., the anaesthetic should be withheld for some seconds, and the patient allowed to breathe a freer supply of air. Rubbing the lips, by stimulating respiration, will have an indirect influence in helping to improve the circulation. In slight cases of failure the condition of the pulse will probably be improved by these means, and then the administration can be continued; but if, in spite of them, the pulse again fail, a change in the anaesthetic should be made. For instance, if chloroform is being administered, a change to the A.C.E. mixture will often prove of great service. If the mixture were being given in the first instance, some pure ether may be poured on the sponge.

Of course, before any change is made in the anaesthetic, the administrator must make quite sure that the patient is not suffering from an overdose of the one which is already being given, or from too little air being allowed at the same time. It is unwise to change hastily from one anaesthetic to another before reasonable attempts have been made to place the patient in a more satisfactory position with the one already in use.

When all attempts to improve the character of the pulse by means of a freer supply of air, a more carefully regulated supply of the drug, and even by a change to a more stimulating anaesthetic, fail to produce the required result, the situation becomes more serious; and the surgeon should be warned that all is not well. With his consent brandy may be given by the rectum or hypodermically, and a hypodermic injection of Strychnine will often prove of assistance at first, but it is probably wiser not to repeat it. Should the condition of the patient not improve, the administration must be discontinued, the patient's head lowered, and the operation must be stopped, so that artificial respiration may be performed. This, as stated

above, is one of the best cardiac stimulants that we possess.

Saline solution should be injected directly into a vein, or into the areolar tissue of the axilla, and the addition of one drachm of the ordinary solution of Adrenalin to each pint of fluid injected is often of great service.

When much blood has been lost the limbs should be bandaged from their extremities, and the patient must be kept warm.

The injection of fifteen minims of the Inj. Ergotae Hypoderm (B.P.) has lately been strongly recommended, and this may be repeated in twenty minutes.

CHAPTER III

NITROUS OXIDE ; NITROUS OXIDE AND OXYGEN

NITROUS oxide (N_2O) is a colourless gas with very little odour, a faint sweet taste, and a specific gravity of 1·527. As an anaesthetic agent it is commonly spoken of as "gas."

At a temperature of 7° C. (44·6° F.) and at a pressure of 50 atmospheres the gas becomes liquid ; and it is generally supplied in this form, in strong iron or steel cylinders, containing 25, 50, or 100 gallons of the gas, 50 gallons weighing about 15 ounces. Liquid nitrous oxide is easily affected by heat, and the cylinders should not be exposed to it, as explosions have occurred. In these cylinders it may be kept for practically any length of time ; but if it cannot be obtained in this form it may be made fresh.

For an account of the manufacture of nitrous oxide, the detection of its impurities, etc., a text-book on chemistry should be consulted.

As an anaesthetic agent nitrous oxide may be administered in one of three ways ; as

(1) Nitrous oxide alone.
(2) Nitrous oxide with air.
(3) Nitrous oxide with oxygen.

In whichever way it is administered, it is the safest anaesthetic that we possess. Very few deaths have occurred under the gas either pure or when mixed with air, and in those that have been reported the fatal result

appears to have been due to deprivation of oxygen, rather than to the effect of the gas. Though very rare in a patient inhaling nitrous oxide, syncope is not unknown. No death due to the inhalation of gas and oxygen has been reported.

Nitrous oxide also possesses great advantages both on account of the very few preparations which are necessary before the administration, the absence of any unpleasant taste or smell in the gas, and the rapid recovery from its effect, with freedom from unpleasant symptoms.

It is well that the patient should not have a heavy meal within an hour or two of the administration, but the dieting which is so important before the inhalation of the other anaesthetics is quite unnecessary. Nervous patients and children should have the bladder empty when taking gas, as if it is full, its contents may be expelled when consciousness is lost.

As a rule the patient is perfectly able to stand up and walk away within a very few minutes of the administration.

Speaking in general terms, nitrous oxide may be given to any patient who is well enough to take an anaesthetic, but in the case of young children, old people, or patients enfeebled by disease, air or oxygen should always be added to the gas. The use of nitrous oxide in dentistry will first be considered, and then its administration for minor surgical operations.

Nitrous Oxide free from Air

The Apparatus

The best apparatus for the administration of nitrous oxide, either pure or with air, is that of Hewitt.

It consists (see Fig. 7) of two *cylinders* filled with liquid gas, placed horizontally side by side, and coupled together by what is known as a " double union," which allows the

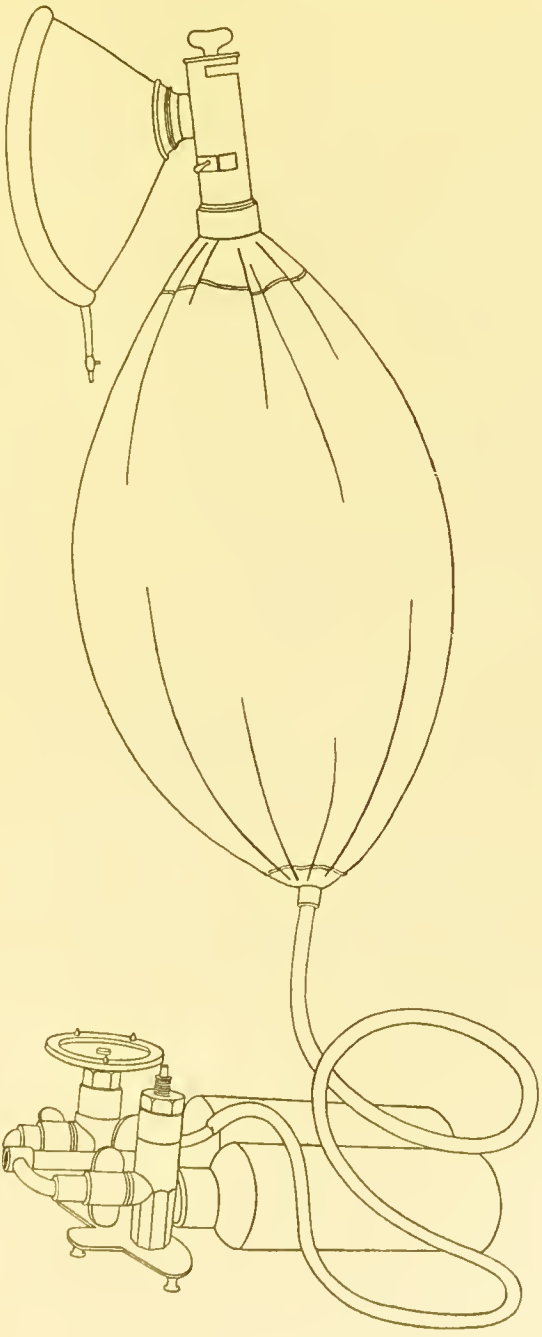

Fig 7.—Hewitt's Gas Apparatus

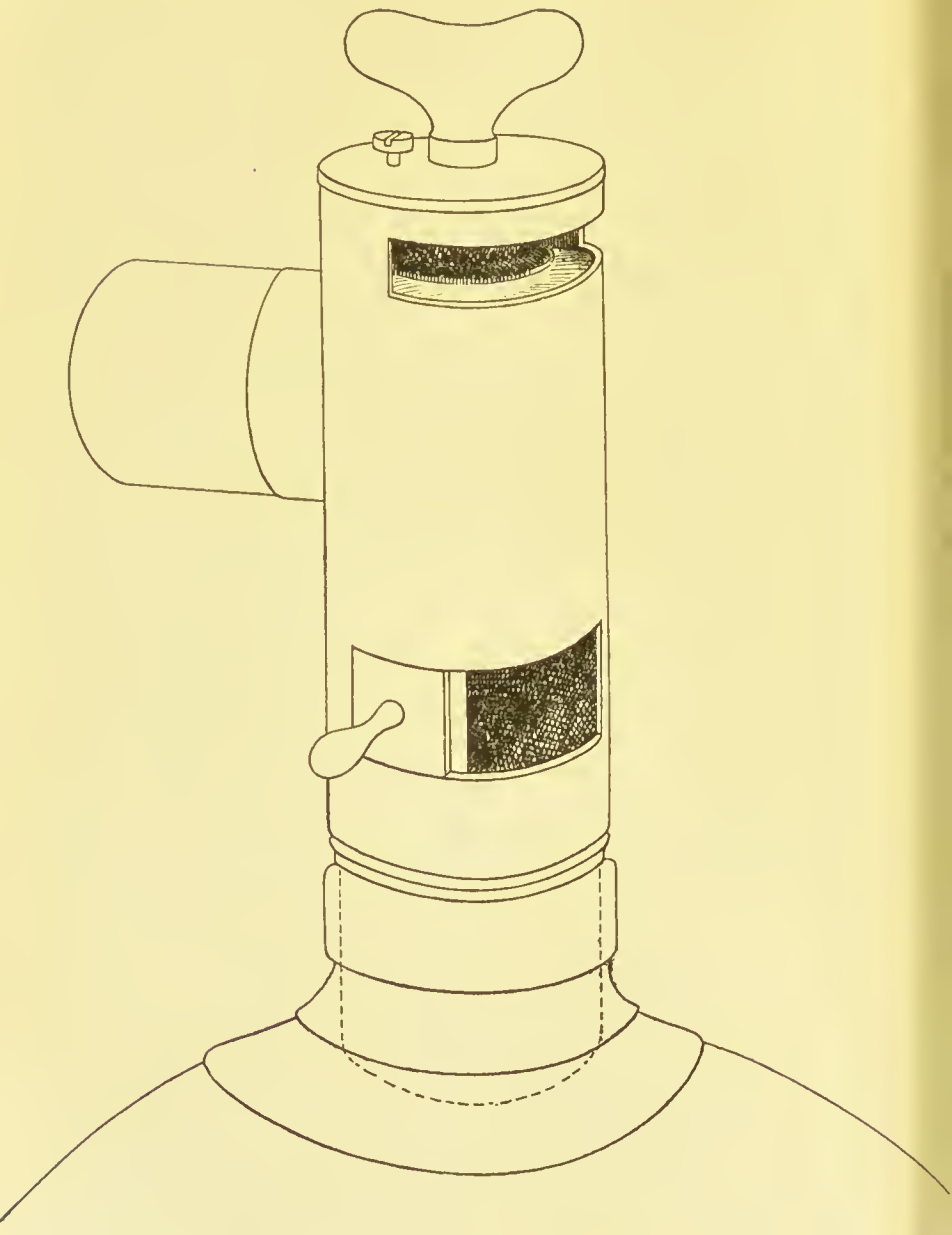

Fig. 8.—Stopcock of Gas Apparatus

gas liberated from either of the two cylinders to pass through the tube into the bag.

The *bag* is made of india-rubber, and generally holds two gallons. There is a tap at the lower end, and when this is turned the bag may be removed without the gas in it escaping (see p. 145). To the upper end of the bag is attached the stopcock containing the valves, on the proper working of which the success of the administration depends.

The *face-piece* which fits on to the stopcock is made of leather covered with india-rubber, and with an air-cushion round its edge. This may be distended through a small tap connected with the lower end. Face-pieces of three or four sizes will be required, as it is important that one should fit the patient's face fairly accurately.

The *stopcock* (Fig. 8) containing the valves will be described in detail, as its mechanism must be understood before it can be satisfactorily used.

There are four apertures in the stopcock, one opening directly into the gas-bag, one opening into the face-piece, and two slots, the lower and the upper, opening to the external air, which may be closed respectively by means of the handle and the tap.

Inside the stopcock (Figs. 9 and 10) are two india-rubber *valves ;* a larger, the inspiratory valve (I.V.), allows the air or gas, as the case may be, to be inspired into the face-piece. When expiration takes place this shuts down, and the current of air or gas escapes through the smaller valve, the expiratory (E.V.), and out through the upper slot.

When both the slots are open, air enters through the lower, passes through the inspiratory valve, into the face-piece and the patient's mouth. Then expiration takes place, the inspiratory valve closes, and the breath passes through the expiratory valve, and out through the upper slot. When the upper slot remains open, and the lower

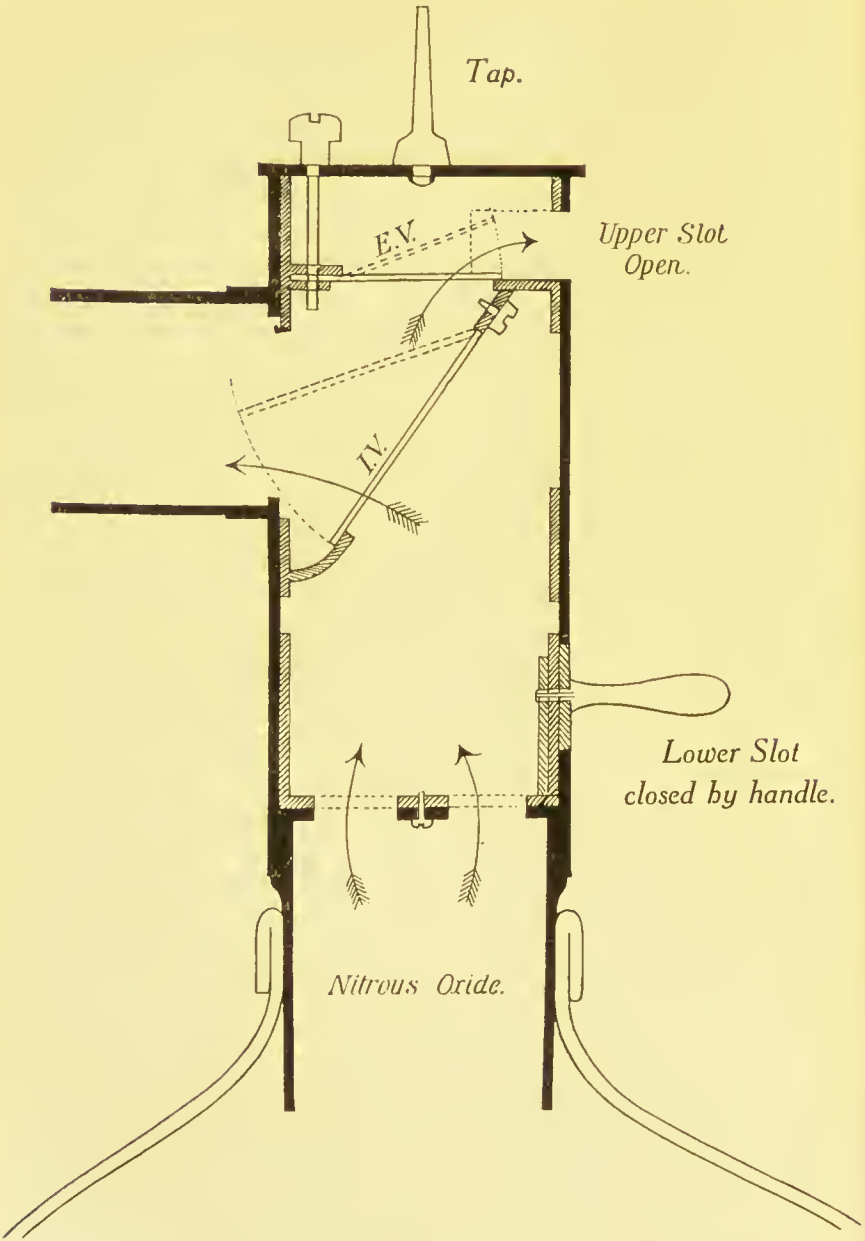

FIG. 9.—SECTION THROUGH STOPCOCK OF GAS APPARATUS. Showing the action of the valves

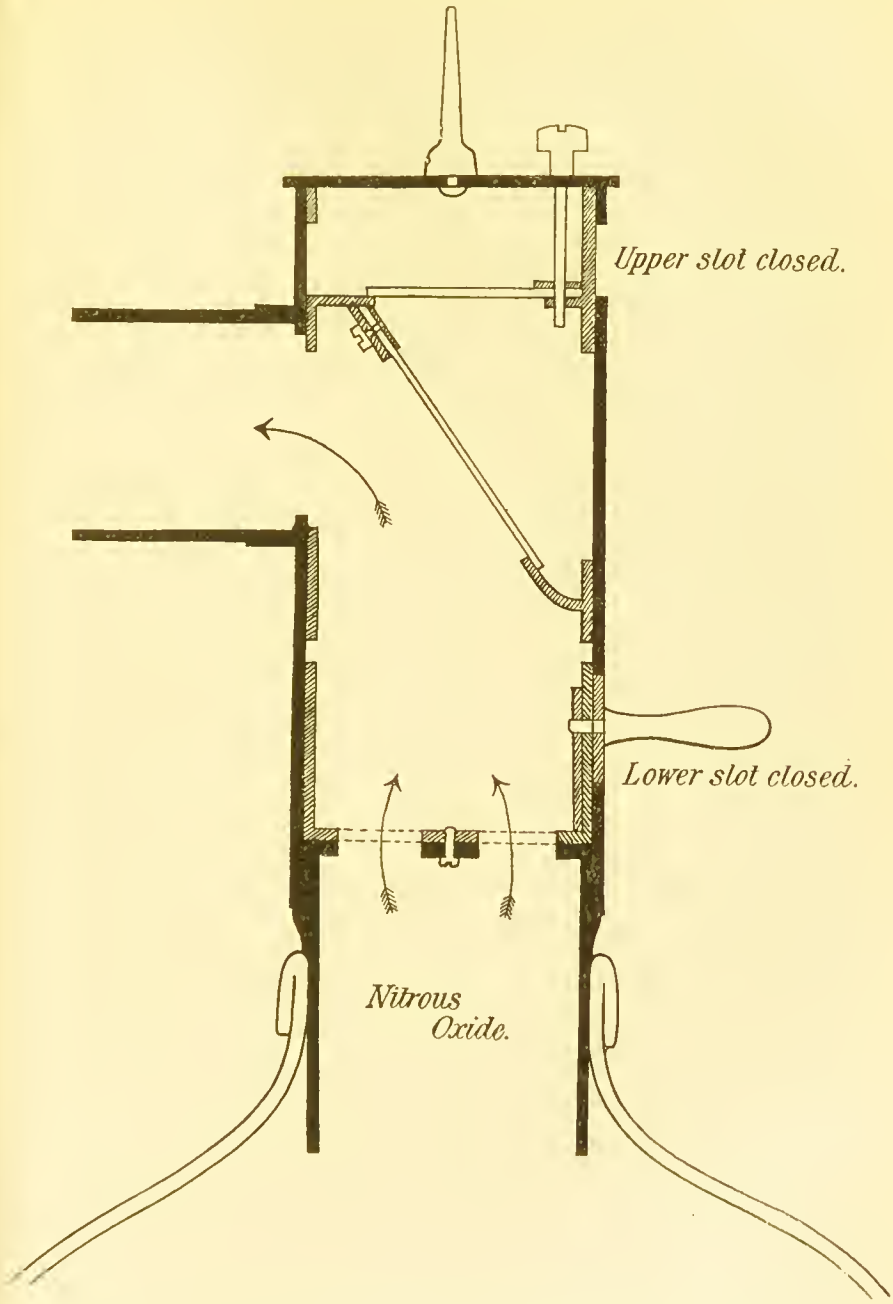

FIG. 10.—SECTION THROUGH STOPCOCK OF GAS APPARATUS. Showing the valves out of action, and rebreathing taking place

is closed by means of the handle, communication is established between the gas-bag and the stopcock, and the air is cut off. During inspiration, gas instead of air now passes through the inspiratory valve and the face-piece into the patient's mouth, and the breath mixed with gas passes during expiration as before through the expiratory valve, and out through the upper slot.

When the tap at the upper part of the stopcock is turned, not only is the upper slot closed, but both the valves are thrown out of action. This is done by means of the rotation of the tube on which the valves are fixed, and to understand the mechanism the apparatus should be examined.

With the upper slot closed and the lower open, air is breathed backwards and forwards without the interference of any valves. With both slots closed gas instead of air is breathed backwards and forwards without any action of the valves.

If the india-rubber valves are not in fairly constant use they are liable to become dry, and their edges curl up ; but if a small piece of aluminium is fixed to the india-rubber it makes the valve more rigid, and prevents curling.

The administration is commenced with both slots open, the patient breathing air in and out through the valves. When these are working satisfactorily, it is obvious that the face-piece is fitting, and gas is then turned on by closing the lower slot. Gas is now breathed in from the bag, through the inspiratory valve, and is expired, mixed with the breath, through the expiratory valve and the upper slot. This breathing through the valves is, as a rule, kept up to the end of the administration.

Re-breathing nitrous oxide, though a good anaesthesia results, should not be a routine practice, as it is more often followed by headache and giddiness, and the interior of the bag is contaminated. It becomes necessary, however,

when the supply of gas fails, when a cylinder is emptied during an administration and some difficulty is experienced in starting the second one, and when nitrous oxide is followed by ether (p. 144) or ethyl chloride (p. 110). Re-breathing takes place when both slots are closed.

The gas is turned on by a "key." This is a metal disc from which are several projecting points, by which a firm hold can be obtained when the sole of the boot is pressed on to the key. If, as is generally most convenient, the gas is being turned on with the right foot, it should be placed on the key in an everted position, and then rotated in the way in which a screw-driver is used to remove a screw that is firmly fixed. To cut off the gas, the foot must of course turn as a screw-driver does in driving a screw home. The gas should never be turned on suddenly, or in too large a stream, as by so doing the aperture of the cylinder may become frozen up, and so it is better to keep the key rotating backwards and forwards. When the administration is finished, and the gas is being finally turned off, the key should be firmly turned, but not with a jerk, as this may lock it so that it will be difficult to move the key when the gas is next required.

Several means have been tried to diminish the noise made by the gas escaping from the cylinder into the bag; but these are not necessary if care is exercised in turning the key, and the bag is half distended before the patient comes into the room.

A full cylinder may be distinguished from an empty one by the difference in weight, and to some extent by the quality of the sound which it gives out when tapped with another piece of metal, such as the key.

Besides the apparatus just described, the anaesthetist must be provided with a good gag, tongue-forceps, a wooden wedge, and an emergency case for the treatment of any possible accident (see p. 1). In dental operations

a form of gag in which the ends overlap is useful, as it may be inserted more easily. **Mouth-props**, with which to keep the mouth open when the patient is anaesthetised, will also be necessary.

These are made of many different materials, and in many shapes (Fig. 11), but those shown in Fig. 11*a* are the best. They are made of aluminium, and can be easily cleaned, and if necessary boiled. Their extremities are covered with small pads of india-rubber, which can be easily detached and cleaned in a weak solution of carbolic acid.

a *b*

Fig. 11.—Mouth-Props. *(a)* Aluminium with india-rubber pads at each end —one shown with pads, and one without; *(b)* small prop of hard wood

Others are made of hard wood, and some are made of wood with pads of india-rubber at their extremities.

No prop should ever be placed in a patient's mouth without being attached to another by a piece of strong catgut. Children and nervous patients are liable to displace the prop with their tongue, and if it is unattached it may be partially swallowed, and give rise to some difficulty of breathing, or an inclination to vomit.

A small prop of hard wood (Fig. 11*b*) or vulcanite, of a much smaller size than those mentioned above, is very useful in those cases of alveolar abscess, etc., where the patient cannot open the mouth sufficiently wide for the insertion of one of the other props; and a wooden or vulcanite prop of a size even larger than the largest of the set

of five mentioned above is occasionally useful for persons who are almost edentulous.

In order to catch teeth, or portions of teeth, that fly back from the forceps, and are thus likely to enter the larynx, a wire spoon has been invented, as shown in Fig. 12. This is held by the administrator behind the part of the mouth in which the dentist is operating, care being taken that it does not interfere with the operation. The bicuspids are the teeth most likely to give trouble in this way.

The Preparation of the Patient

As before stated, this is simple, but it is preferable that no solid food should be taken for one or two hours before

Fig. 12.—Oral Spoon for Catching Fragments of Teeth

the administration. It is, however, important that no alcohol should be taken just before, as the anaesthesia will then be very short, and there will probably be much reflex movement and excitement. Children and nervous patients should have their bladders empty.

The most important point is to make sure that the breathing of the patient is not hindered by any clothing. In the case of men the collar should be removed, and, if necessary, the shirt unfastened at the top. If the trousers are tight at the waist, the upper two or three buttons should be unfastened. In women, corsets and neck-bands, unless quite loose, should be unfastened, and when the patient is in the chair the waistband of the dress should, if necessary, be undone. Some people are apt to imagine that their clothing is quite loose, while it is obviously

tight, and some persuasion may be necessary before a reasonable condition is obtained. The feeling of suffocation experienced by some patients in taking gas is generally due to respiration being hampered by tight clothing.

Before the patient enters the room the gas-bag should be half filled so that he is not startled by the noise which is sometimes made when gas is first turned on ; but the bag must not be so distended that, when the lower slot is closed, gas is forced into the mouth.

The anaesthetist should also breathe through the apparatus to see that the valves are in working order. The inspiratory valve will occasionally be found to have partly entered the aperture which it is to close, and must be replaced in position. The valves may be found curled up at the edges, and so the apertures will not be completely closed. The upper part of the stopcock should then be placed for a few seconds in warm water, till the valve at fault is immersed. This soon renders it supple again, and its aperture will then become perfectly closed. Both the above occurrences are less likely to happen if the valves are strengthened by a small piece of aluminium as suggested above.

The Position of the Patient

The patient now takes his place in the chair, and the position he assumes is not unimportant. It should be a comfortable one, and must meet the requirements of both the administrator of the gas and the operator. He should be instructed to sit as far back in the chair as possible, and not rest on the edge of the seat, and then lie back. The legs should not be crossed, or much flexed. The feet should be placed, if possible, on the rest provided for them, but if the patient is very tall it is better that they should rest on the floor, than that the legs should be too much flexed. The feet should not be fixed in any position, nor

even pressed firmly against the foot-rest, for any constrained position is liable to be followed by opisthotonus when the patient becomes unconscious.

The position of the head is most important. It should be kept as much as possible in the continuation of the long axis of the body ; that is to say, it must not be unduly bent back, nor, on the other hand, must the chin be pressed down towards the sternum.

If the operator wishes to have the head thrown far back while he is at work, a small air-cushion may be placed behind the head as suggested by Hewitt. This is distended at first, and enables the administrator to have the head fairly well forward while the patient is being anaesthetised, and when he is ready for the dentist the air may be allowed to escape from the cushion, when the head will fall back into the position desired by the operator. If the air-cushion is not at hand, the position required by the dentist may be obtained by tilting back the chair when the patient is unconscious.

The patient should be advised to place his hands on the arms of the chair, and in this position will, if nervous, probably grasp them firmly as he becomes unconscious, rather than move them about to the inconvenience of both the administrator and operator. If this position is not satisfactory he should clasp his hands.

Placing the Prop in Position

Any loose teeth or plates must be removed, and the prop should now be placed in position. This will generally be on the side of the mouth opposite to that from which the first tooth is to be extracted ; but if the tooth is situated in the front of the mouth, a small prop may occasionally be placed behind it on the same side, and so later on the use of a gag will not be necessary when teeth are also to be removed from the other side as well. Care must be taken

that the prop rests on sound teeth, or firm gum, that it keeps the mouth sufficiently open, does not easily slip, and that it will not be in the way of the operator.

If some teeth have recently been removed from the side on which the prop has to be placed, it should be kept from pressing on the gum, which will probably be sensitive. When teeth are to be removed from both sides of the mouth a central prop is sometimes placed between the incisor teeth, but this practice is open to the objection that the patient may injure the teeth if he bites firmly ; and also when placed in this position the prop is more liable to become displaced by his semi-conscious efforts. It is, however, useful from the fact that it does away with the necessity of changing from the prop to a gag during the operation. Before the face-piece is applied the dentist should always be consulted as to whether sufficient room has been obtained.

When a patient is suffering from an alveolar abscess the amount of opening of the mouth that can be obtained by any prop is often very small. In these cases a small prop should be placed between the teeth in front of the one to be removed on the same side of the mouth, or if a small enough prop is not at hand, a cork to which a string is attached may be employed. When the patient is anaesthetised a gag is placed on the opposite side, and the prop removed. Occasionally the jaws can be separated to such a limited extent that no prop can be inserted even between the front teeth, and then the patient must be anaesthetised without, and the mouth opened when he is unconscious. This will have to be done with the wooden wedge till an opening is made large enough to admit the gag, which must then be opened to the extent required. For these cases a screw-gag is sometimes useful. If much trouble is experienced in opening the mouth by these methods the anaesthesia obtained from the gas may be insufficient,

and recourse must be had to a prolonged gas anaesthesia by the nasal tube, or to gas and ether.

When the prop is once in a satisfactory position care must be taken that it is not displaced by movements of the tongue, or by the opening of the mouth. It is less likely to be displaced if the patient is instructed to close the lips over it.

The Face-Piece

A face-piece must now be selected, and attached to the gas apparatus, the air-cushion surrounding it having been fully distended. If afterwards it is found that the face-piece fits better with the cushion less distended, it is easy to let a little of the air out ; but if more distension is required, it will be necessary to remove the face-piece from the patient's face. A few drops of Eau de Cologne sprinkled on the inner surface of the face-piece will disguise the smell of the india-rubber, which some people find unpleasant.

Position of the Administrator

The anaesthetist in administering gas usually stands on the left side of the patient, and is thus entirely out of the dentist's way when he wishes to operate from behind the chair. Some administrators, however, stand at the back of the chair.

The right foot should rest firmly on the key by which the gas is turned on, and the cylinders must be placed at a suitable distance, so that the administrator may have complete control over the apparatus. Before the face-piece is finally applied the patient should be instructed to breathe freely into the apparatus. Many are inclined to hold the breath at first, but when told to " blow out " into the bag, will do so readily, and this deep expiration must be followed by a long inspiration, and a regular rhythm will soon be established.

Holding the Face-Piece

With the administrator standing at the left of the patient, the face-piece will naturally be most conveniently held in the left hand. The best way of holding it is shown in

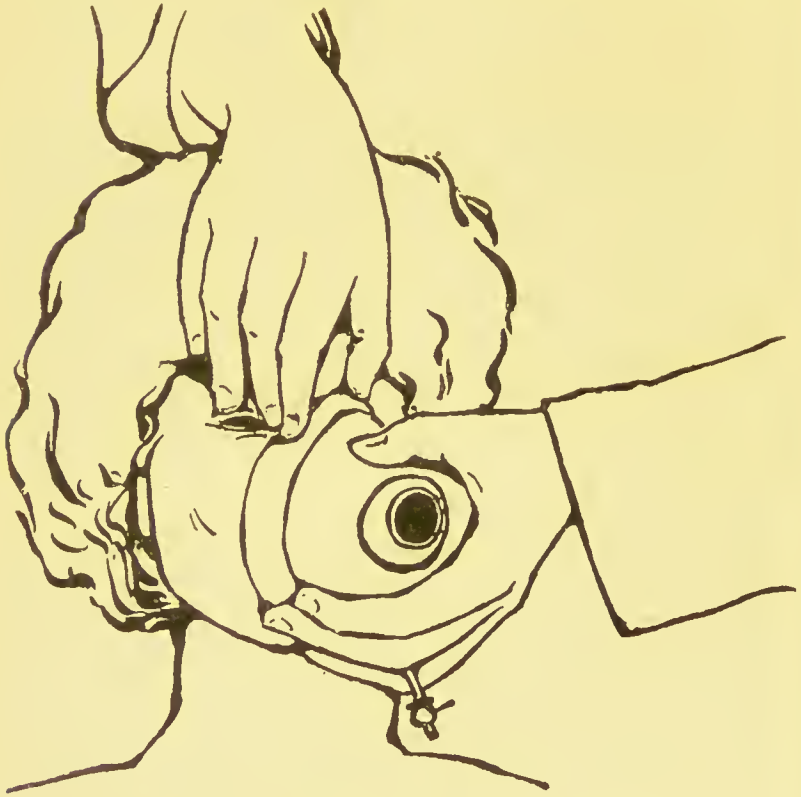

Fig. 13.—Method of Applying Face-Piece for the Administration of Nitrous Oxide

Fig. 13, where it may be seen that the thumb is resting on the part of the face-piece which is above the connection with the stopcock, while all the fingers are below it.

As the face-piece is applied the upper part should be allowed to slide down the bridge of the nose to a slight extent to ensure its fitting in this part, which is one where

the gas is most liable to escape through careless approximation. When the upper part has been placed in position the lower part must be carefully applied. The accurate fitting of this part will be assisted by placing one, two, or even three fingers under the chin. These fingers will serve other useful purposes. With them the chin may be lifted forwards from the sternum, and thus the air-way may be to some extent made freer. Some nervous patients, especially children, are inclined to displace the prop which has been placed between their teeth, and even to force it out into the face-piece, or allow it to pass to the back of the mouth, and be partially swallowed. This can be prevented to a great extent by firm pressure with the fingers under the jaw.

If the thumb is placed on one side of the face-piece, and the fingers on the other, there is a tendency to compress the sides. In this way the face-piece will be elongated, and probably will fit less accurately; and the fingers cannot be used in the methods described above.

If in spite of all care the face-piece seems to be allowing gas to escape round the bridge of the nose, that part may be compressed by means of the thumb and first finger of the right hand, as shown in the figure. The face-piece will fit much better when held lightly against the face than if force is employed to press it there, and, if the patient is suffering from an alveolar abscess, much pain may be caused by too firm pressure. An inexperienced administrator when turning on more gas into the bag is very apt to steady himself by allowing some weight to rest on the face-piece; this must be carefully avoided.

When a face-piece of the right size has been adjusted, and both slots of the stopcock are open, the patient will be breathing air through the valves; and, if these are working satisfactorily, the expiratory valve will be seen to rise and fall rhythmically, and the regular sound

produced by the action of the valves will be heard. The movements of the expiratory valve may be very slight if the respirations are feeble, or if the face-piece is not fitting accurately; but the patient should not be allowed to inhale gas till the apparatus has worked satisfactorily during the inhalation of air. As soon as the valves are acting well the administrator should start the inhalation of the gas by turning the handle (Fig. 9) which closes the lower slot of the stopcock, and cuts off the air at the same time that it establishes communication between the face-piece and the gas-bag.

Changing Cylinders

If, during the administration, the cylinder is emptied, the tap at the top of the stopcock should be promptly turned, so that the patient may have sufficient gas to re-breathe till the other cylinder is ready for use.

When changing from one cylinder to another the first one should be turned off firmly, the key removed, and placed on the second cylinder, and the gas from that allowed to flow into the bag. When the second cylinder is working satisfactorily the tap of the stopcock may be turned back, and the patient again allowed to breathe through the valves; but if, as sometimes happens, the second cylinder is also found to be empty, the patient must re-breathe the gas which is in the bag till anaesthesia is complete.

The Administration

When the patient is taking gas the room should be kept as quiet as possible, and no remarks about the operation should be made till it is certain that the patient is unconscious. If the chair require raising or lowering for the convenience of the operator, this should be done either before the administration is commenced, or when the patient is unconscious.

The breathing of patients inhaling gas, as with any other anaesthetic, is subject to many variations, both in rate and depth. Many hold their breath as long as possible, while others take enormously deep inspirations from the very start. If the patient seems to be breathing satisfactorily, and yet very little sound comes from the valves, it is probable that the face-piece requires more accurate adjustment.

For the majority of patients it will be sufficient to keep the bag about half full. For hysterical persons who are inclined to make a noise, or become violent in their movements, or strong men who seem inclined to struggle, the bag may be distended, or an extra amount of gas given for a few inspirations by compressing the bag with the hand.

In the great majority of cases the inhalation of nitrous oxide is not unpleasant to the patient.

An analysis of the sensations felt during the administration is naturally imperfect ; but the general experience after a few inspirations is that of passing into a pleasant sleep. A feeling of slight numbness or tingling is sometimes felt, beginning in the feet and travelling upwards, and though efforts may be made from time to time to do some voluntary action, as the lifting up of a hand, this will soon cease from a feeling of laziness. As the inspirations become deeper and the pulse fuller, more pronounced sensations are noticed. Noises are heard, and are described as those heard when a train is rushing into a tunnel, or at other times as music. It is curious that though at the time the dream seems extraordinarily real to the patient, yet on recovering consciousness after comparatively few seconds, he is quite unable to recall it. Erotic dreams may occasionally be experienced.

If the operation has been completed before any return to consciousness, the first sound that will affect the patient will probably be the request for him to expectorate the

blood which he finds in his mouth. If the operation has been allowed to go on too long the patient may experience a bad dream, which will have some connection with the pulling out of a tooth, or he may even be sensible of the last extraction. Too much reliance, however, must not be placed on the statements of a patient recovering from the effects of nitrous oxide as to the account of the operation that he has felt. A very nervous patient who knows beforehand which teeth are to be extracted, may declare that he has felt all the teeth being removed. It may sometimes be proved that he has not by asking which came out last, and a tooth on one side of the mouth may be indicated, while in reality the last tooth extracted was situated on the opposite side. If the prop is left in position for some seconds after the extraction of the last tooth, its removal may be noticed by the patient, and described as the extraction of a tooth.

The induction of anaesthesia by nitrous oxide is so rapid that it is unnecessary to divide it into stages, though this might be done as with other anaesthetics, with the exception that in this case the corneal reflex is not generally lost when the patient is ready for operation. The first effect of the inhalation which becomes apparent to the anaesthetist is generally the duskiness of the skin, noticed in the face, and increasing till in the end it results in a state of *cyanosis* or extreme lividity. The breathing after a time becomes deeper and deeper, and a loud sound, described as *stertor*, will be heard.

The term " stertor " is used somewhat vaguely for the sound produced by some obstruction to breathing in the upper part of the air-way ; but as one of the signs of anaesthesia by nitrous oxide, one distinct form of obstructed breathing is always indicated. It differs from the other forms in being spasmodic and irregular, and is most probably produced by muscular contractions which elevate

the larynx, and thus partly close its superior aperture by bringing it into contact with the epiglottis and the base of the tongue. Whatever its exact mechanical explanation, it is clinically due to deprivation of oxygen, and when this "stertor" is well established, no more gas should be administered. When nitrous oxide is not pushed to such a degree as to produce this form of stertor, especially when air or oxygen is administered with it, instead of this irregular and spasmodic sound there will generally be heard a deep regular snoring, which may be produced by the vibration of the soft palate, or by that of the arytaeno-epiglottidean folds.

The third special result of the inhalation of nitrous oxide is the onset of irregular muscular contractions, known as *jactitations*. These movements may be ushered in by slight twitchings of the orbicularis palpebrarum, but the arms soon become affected. The movements may be clonic in character, and to these the term "jactitation" is more properly applied; but tonic contractions are also common, and in some cases there is marked opisthotonus, which in some patients is extremely inconvenient, as the back becomes so arched that the head is forced out of the rest, and is thrown so far back that the extraction becomes very difficult, if not impossible. Opisthotonus is common in children, and it is among this class of patient that the bladder and even the rectum are emptied during anaesthesia.

As the inhalation proceeds the pulse is quickened, and becomes fuller in volume. The pupils generally dilate, and there may be an interval between the lids, and the globes are often rotated upwards. As the reflex is not always lost by the time the patient is ready for the operation, it is not very valuable as a sign of anaesthesia with this particular agent; but this is of small importance, as the preceding signs are so obvious as to be unmistakable.

When to Remove the Face-Piece

If the operation to be performed is a very short one, such as the extraction of a single tooth that is already loose, sufficient time may be obtained if the face-piece is removed as soon as the patient begins to show much cyanosis with the first advent of twitching round the eyes, or the first sound of stertor. If, however, the operator requires as much time as he can get, the administration may be continued till jactitations are observed, but a much better anaesthesia will be obtained by combining air or oxygen with the nitrous oxide. In the second of these cases the conjunctival reflex will probably have disappeared by the time that the inhalation is discontinued ; but in the former case a good anaesthesia can generally be obtained for a short operation without the reflex being lost, and it is best to work by the other signs as mentioned above.

Length of the Administration

The time required to produce anaesthesia varies within wide limits. Very few inspirations of gas will suffice to anaesthetise a child, especially if weak and anaemic, while a strong alcoholic man will obviously require a much larger quantity.

Besides the general condition of the patient, the duration of the induction of the anaesthesia is affected by the rate and depth of the breathing, the fitting of the face-piece, etc., and the amount of distension of the gas-bag. The time given by various writers as the average of a considerable number of administrations varies from 50 to 70 seconds.

Quantity of Gas Inspired

The average amount of gas inhaled is given as six gallons ; but a child is sometimes completely unconscious after six or seven breaths, while an adult who is addicted

to alcohol, or is in the habit of taking large quantities of such drugs as morphia, will require much more than six gallons.

Some patients present themselves for the administration of gas who have taken a dose of alcohol within a few minutes of entering the room. In these, large quantities of gas may be given without a very satisfactory anaesthesia being obtained, which will probably be of quite short duration, and accompanied by a considerable amount of movement and phonation.

Duration of the Anaesthesia

This will also vary within the same wide limits as the time occupied by the induction. A child will soon show signs of returning consciousness, while in adults the period during which the operation may be continued will be much longer. As a general rule, a long induction is followed by a long anaesthesia.

The average duration of the anaesthesia resulting from the administration of nitrous oxide without any air is given by different writers as varying between 25 to 40 seconds. If children and anaemic girls were excluded, the average would probably be about 35 seconds.

Signs of an Overdose of Nitrous Oxide

These are practically the exaggeration of those which are taken as the signs of anaesthesia, that is to say, increasing cyanosis, stertor very loud for a time and then stopping, and finally cessation of respiration. The way in which death might be produced by determined pushing of nitrous oxide would be by primary respiratory failure, followed by failure of the circulation. This respiratory failure would be caused in two ways : (1) by an exaggeration of the obstruction of the air-way, which by its evidence as stertor is taken as one of the signs of anaesthesia, and (2) by an

obstruction to respiration through spasm of the respiratory muscles similar to that which occurs in the muscles of the extremities.

Whether caused by one or both of these factors, it is certain that we may expect the circulation not to fail till after the respiration has first stopped, and so we have an opportunity to prevent death by restoring the respiration before the circulation becomes affected to any serious extent. For the treatment of respiratory failure, and to prevent repetition, the reader is referred to p. 39.

Though very uncommon, and probably only in patients with cardiac disease, it is possible for syncope to occur while nitrous oxide is being administered, as indeed it may occur without the administration of any anaesthetic ; for treatment see p. 52.

The Operation

When the administrator is satisfied that the patient is nearly ready for operation, before removing the face-piece, he should warn the dentist, so that the first and deepest part of the anaesthesia is not wasted. In the removal of the face-piece the anaesthetist should be careful to keep it well out of the way of the operator.

As soon as the operation is commenced the administrator should do all in his power to help the operator. In the first place, the head should be kept steady in the required position. If the upper jaw is the seat of operation, a hand should be firmly placed on the uppermost part of the head, and when the forceps are being driven up into the socket of the tooth, a certain amount of counter pressure should be exerted against this force. If the teeth are being removed from the lower jaw, no attempt must be made to regulate the extent to which the mouth is opened, as the dentist will have control of this movement, and must not be interfered with, but the opposite articulation may be

steadied by pressure with two or three fingers, and in this way a lower jaw, which is sometimes easily dislocated, may be kept in its place.

By the depression of the lower jaw the nitrous oxide inhaled by the patient is not so easily eliminated, and so the period of anaesthesia is somewhat lengthened; but the anaesthetist must see that respiration is not thus hampered unduly, and when necessary the jaw must be pushed forward, or the tongue drawn out.

If during the operation the patient slips down in the chair so that the chin is forced towards the sternum, there will be very little room for the operator to exert traction in a downward direction, and the head should be slightly turned to one side, so that the operator may have more room in which to work.

When all the teeth have been extracted from the side opposite to that on which the prop has been placed, room is made on the other side by inserting a gag on that from which the teeth have just been extracted, and then removing the prop. For instance, supposing that some teeth are to be extracted from the right side, and then, if time permits, some are to be removed from the left, before the patient is anaesthetised a prop is placed on the left side, and when the teeth on the right side have been extracted, a gag must be inserted on that side, and the prop on the left side removed, so that it does not interfere with the operation.

Before the operation is begun it is usual for the dentist to show the administrator what teeth he wishes to extract, so that some idea can be formed as to the time to change the prop for the gag, but it is not always possible for the anaesthetist to know whether all the teeth have been removed, and it is much better for him to wait till the operator gives the word. When this is done the change must be made as expeditiously as possible, and care must be taken that the gums which are already lacerated from the removal

of the teeth, are not unnecessarily injured by the pressure of the gag. Of course, if a central prop has been inserted in the first instance, and has not been moved, a gag will not be required. Sometimes a prop which has been arranged so as just to give the requisite amount of space for the operation will, on the removal of the face-piece, be found to have been slightly shifted, so that there will now not be quite room enough. Under these circumstances it is best for the operator not to waste time in trying to work in a space that is too small, but the gag should at once be placed in a suitable position, and the prop removed. If the prop has only moved a very little, it may occasionally be pushed back into its place by one finger, and kept there by the anaesthetist.

When the gag is in position, it must not be opened more than the operator requires, and it must not stretch the cheek too tightly, as extraction is then rendered more difficult.

The entrance of foreign bodies into the larynx may be prevented by means of the spoon shown in Fig. 12, or if this is not at hand, the corner of a napkin may be placed in the mouth behind the seat of the operation.

The anaesthetist can render great assistance to the dentist in many ways, as for instance the steadying of the head in the best position, sponging the blood away when the lower teeth are being removed, and preventing any portions of teeth from being left on the tongue, and thus exposing the patient to the risk of having them carried into the larynx by the first vigorous inhalation. The more a dentist works with one administrator, the greater will be his ease and confidence, and the more will he be able to do during the same period of anaesthesia.

Signs of Returning Consciousness

As the effects of the gas pass off, the colour of the patient will gradually improve, the cyanosis growing less, and the

normal red colour again appearing in the lips, in fact, a flush is not uncommon for the first few seconds. The dilated pupils slowly contract, the general appearance of the face becomes natural, the respirations become quieter and the pulse slower.

If the operation is continued after consciousness has returned, the patient will generally show that pain is being felt by phonating, or screaming loudly, and by movements of the hands and feet. But screaming, and movements of the hands and feet do not certainly show that the patient is actually feeling pain. They may be entirely reflex, and after a piercing scream or violent movements of the hands, the patient, when asked on fully returning to consciousness, will often deny that he has felt anything of the operation. Some patients, especially nervous women, will be noisy from the commencement of the administration, but in this class of case the sounds generally become shriller when any pain is being felt, and a little practice will enable the administrator to recognise this difference. In hospital practice it will often be noticed that after one female patient has been very noisy the others following her will in their turn give way to screaming, and so those who are waiting for the administration of gas should be prevented from having their natural nervousness increased by hearing the screams of the patient whose turn comes before theirs.

The dentist is as a rule perfectly ready to stop when the administrator tells him that the patient is feeling pain, and it is most important that a patient who has to undergo several administrations should not be allowed to feel pain with the first. If any doubt is felt by the anaesthetist as to whether consciousness is present or not, it is much better to be on the safe side, and to stop the operator too soon, rather than let the patient suffer pain. Even if the actual wrench of the extraction is not distinctly felt, a

confused nightmare of a painful character is experienced, which may be much more unpleasant than ordinary pain.

The Recovery from Nitrous Oxide Anaesthesia

When the operation has been concluded the prop should be removed from the patient's mouth, and the head bent forward so that the blood may run into a bowl, and not be swallowed. No attempt should be made to remove the prop while the patient is biting on it, or he may imagine that another tooth is being extracted. Some warm water will now be given with which to wash out the mouth, and he must be warned not to swallow it, as nausea and even vomiting may result.

As a rule the patient will by this time feel recovered from the effect of the anaesthetic; if, however, he feels faint, he should be allowed to rest in the chair for a few minutes, while the windows are opened, so that he may breathe fresher air. If there is any tendency to syncope, or even a feeling of faintness, some smelling salts or ammonia may be held to the nose. Some patients at this stage become noisy, while others are very lethargic and slow to recover their normal vivacity, but it is very rarely that a patient has not perfectly recovered in ten minutes after the conclusion of the operation. He should be advised not to talk much soon after the administration of gas, but should go home, and, if not feeling well, lie down for an hour or so. Though feeling perfectly well directly after the recovery, a patient may complain of headache or lassitude on the next day.

Ordinary food may be taken as usual, but it is better to allow an interval of an hour before solid food.

Nitrous Oxide mixed with Oxygen

By the addition to nitrous oxide of a suitable quantity of oxygen, either pure, or as atmospheric air, a good

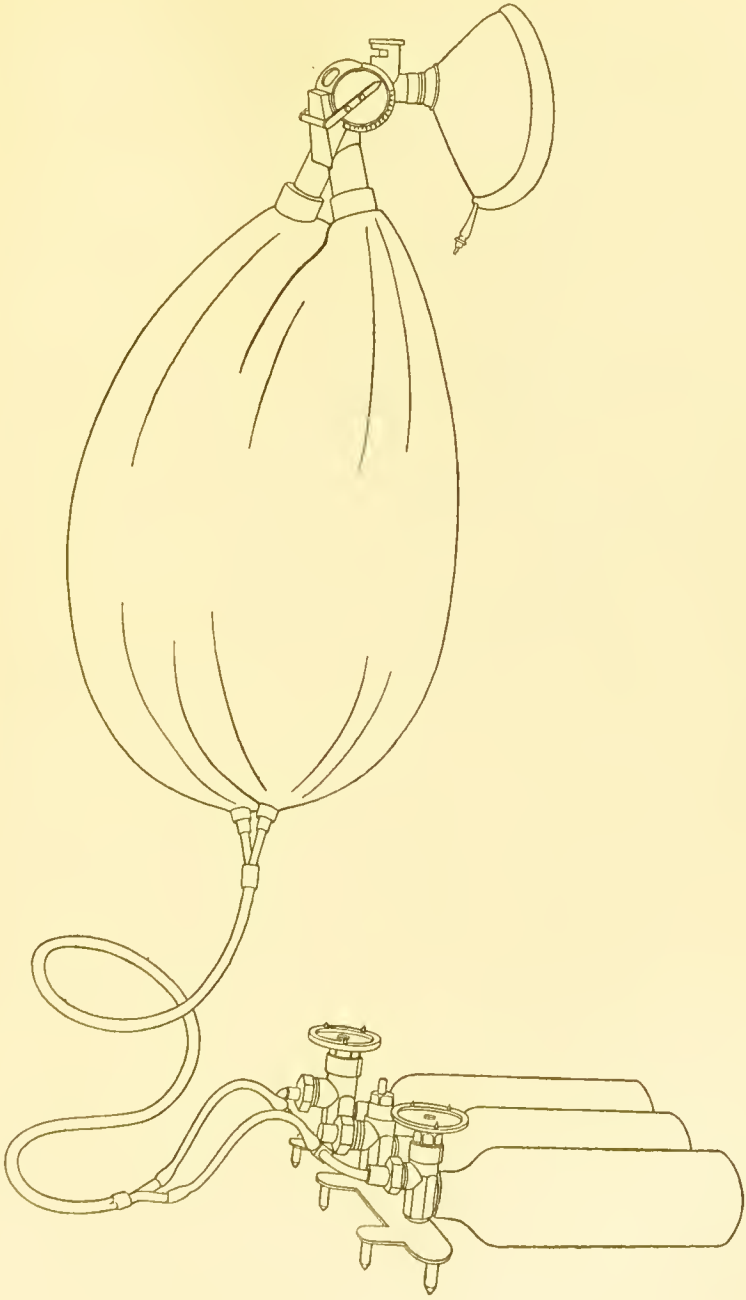

FIG. 14.—HEWITT'S GAS AND OXYGEN APPARATUS

anaesthesia may be obtained without the phenomena usually observed when nitrous oxide alone is inhaled, viz. cyanosis, stertor, and jactitations, which are due not to any specific action of the gas, but simply to the want of free oxygen, which is cut off during the inhalation.

A definite mixture of the two gases was at first inhaled from a large cylinder, but with Hewitt's portable apparatus we are now able to administer gas and oxygen in any desired proportion.

The apparatus (Fig. 14) is necessarily more complicated than that for the administration of nitrous oxide alone. Two india-rubber bags, often joined together down the middle, receive respectively the nitrous oxide and the oxygen from the cylinders. Of these cylinders there are usually three—two of nitrous oxide and one of oxygen. The tube conveying the gases to the bags, though apparently single, is in reality double, and consists of a smaller tube for the oxygen, surrounded by a larger one for the conveyance of the nitrous oxide. These two tubes and the two bags are in some forms of the apparatus kept separate during the whole of their course. When one tube is enclosed by the other considerable trouble may be experienced if the oxygen tube becomes detached from its cylinder without the knowledge of the anaesthetist, and oxygen thus unintentionally mixes with the nitrous oxide in the passage to the bag. As a result of this, the inductions do not proceed in a normal manner, and until the outer tube is removed for examination the administrator may be unaware of the cause.

The gases are thus kept quite apart till they leave the bags at their upper ends. Here they enter a complicated metal stopcock (Figs. 15 and 16), the nitrous oxide passing straight into the "mixing chamber," while the oxygen is conveyed into the "oxygen chamber." The return of the gases to their respective bags is prevented by two

valves in the lower part of the stopcock. The oxygen is shut off from all communication with the mixing chamber while the indicator points to " air " or N_2O, but if this be rotated till it is opposite the figures 1, 2, 3, etc., the corre-

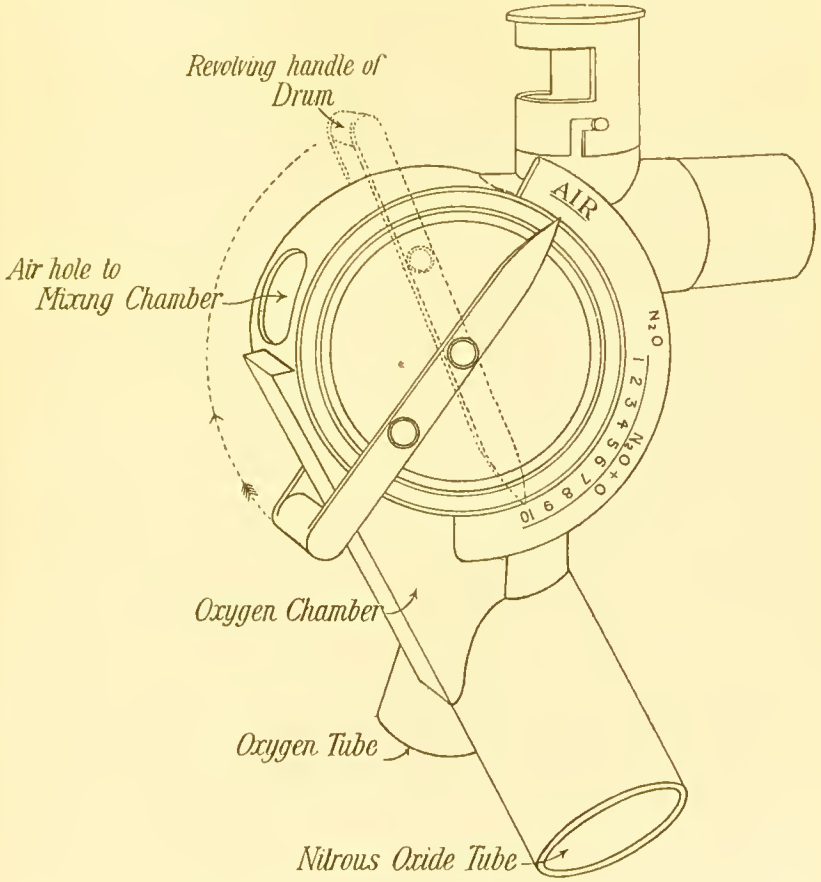

FIG. 15.—STOPCOCK OF GAS AND OXYGEN APPARATUS

sponding number of apertures leading from the " oxygen chamber " to the " mixing chamber " are opened, and a mixture of the two gases results.

The numbers indicated do not represent the exact percentage of the oxygen in the mixture of the two gases,

but the number of the holes through which the oxygen is allowed to enter the mixing chamber. The proportion of

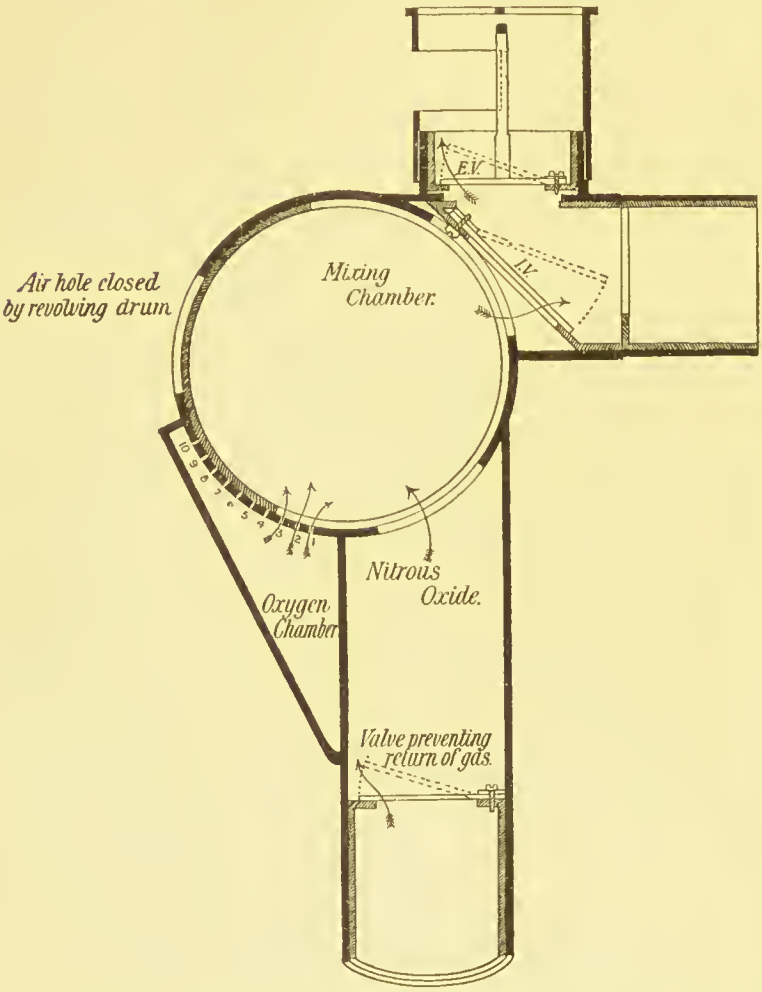

FIG. 16.—SECTION THROUGH STOPCOCK OF GAS AND OXYGEN APPARATUS. The patient is breathing Nitrous Oxide, while Oxygen also is being admitted from the Oxygen Chamber through 3 holes

the oxygen depends somewhat on the size of these holes, which vary slightly in different apparatus. As a rule,

each hole that is opened allows about 1 or 1½ per cent. of oxygen to pass through, but this is only if there is an equal distension of the two bags. For instance, if the oxygen bag is almost empty while the nitrous oxide bag is distended, very little oxygen will pass into the mixing chamber when the indicator is turned; and *vice versâ* if the oxygen bag is fairly full while the nitrous oxide bag has been allowed to become empty, the amount of oxygen that is allowed into the mixing chamber will be much higher than that represented by the figure opposite the indicator.

The indicator is attached to a drum which revolves inside the mixing chamber. When the indicator is opposite "air," air alone is being admitted to the mixing chamber through the open hole; but as the indicator is turned to N_2O the air hole is closed by the revolving drum, and nitrous oxide is admitted to the mixing chamber. As the indicator is still further moved on to 1, nitrous oxide is still flowing in, air is still excluded through the closing of the air hole, and one hole leading to the oxygen chamber is now uncovered, and through it oxygen enters the mixing chamber, and so on.

The inspiratory valve (I.V.) and the expiratory valve (E.V.) are situated at the end farthest from the mixing chamber, and the face-piece is attached to the extremity of the stopcock. As with the apparatus for the administration of nitrous oxide alone, the action of the expiratory valve is the best guide to the efficient working of the apparatus, and the approximation of the face-piece to the face of the patient.

As above stated, the bags should be kept equally distended throughout the administration, and they need never be more than two-thirds full. The nitrous oxide bag, which is usually arranged to be the one next to the anaesthetist as he stands at the left of the patient, requires constant

replenishing, while the oxygen bag, when filled to about two-thirds of its capacity, will last for four or five ordinary dental administrations. On the constant equal distension of the bags a good deal of the success of the administration depends, while another most important factor is the accuracy with which the face-piece is made to fit the patient's face. If it is only carelessly approximated to the face so much air will enter round its margins, that, when combined with the oxygen given in the mixture of the two gases, the total amount of oxygen inhaled by the patient will be out of due proportion to the amount of nitrous oxide. As a result, the patient will either remain a long time without showing any signs of anaesthesia, or will pass into a condition of sleep, from which he will probably be aroused by the first application of the dental forceps.

The Administration

All that has been said under the heading of the administration of pure nitrous oxide as to the preparation of the patient, his position in the chair, the introduction of the prop, etc., and all the remarks as to the management of the operation and after-treatment, etc., apply with equal force to the administration of nitrous oxide mixed with oxygen.

The two bags being equally distended, and a well-fitting face-piece having been applied, the patient is first allowed to take a few breaths through the apparatus with the indicator placed at "air." He is now simply breathing air in through the hole at the uppermost part of the stop-cock, through the inspiratory valve and the face-piece into his mouth, and out again through the expiratory valve. When it is seen by the movement of the valves that the apparatus is working well, the indicator is turned to 2. As explained above, this means that the patient is now inhaling nitrous oxide gas mixed with from about

2 to 3 per cent. of oxygen. After four or five breaths the indicator is turned to 4, when the proportion of oxygen may be reckoned at about 6 per cent. After five or six more breaths the indicator is turned to 6, and may be kept there till anaesthesia is complete, or further advanced to 7, 8, or even 10, according to the requirements of the case. The exact amount of oxygen to be allowed for each patient can only be learned by experience ; but it may be stated roughly that children and anaemic girls require most, while strong men seldom require the indicator to be turned past 6.

If too much oxygen is given, the patient becomes of a florid colour, and is inclined to phonate or struggle. If signs of excitement are noticed the amount of the oxygen should be temporarily diminished, or at any rate the indicator should be kept fixed, and not turned further on till the excitement seems to be abating. A small amount of phonation is more likely to accompany anaesthesia by this mixture than when gas is given alone. It may persist throughout the anaesthesia, but has occasionally been noticed to cease when the forceps have been applied to the first tooth to be extracted.

If, on the other hand, the patient shows any sign of cyanosis, the amount of oxygen should be increased, as if it were allowed to become more marked it might be accompanied by the other asphyxial signs of anaesthesia by pure nitrous oxide, namely, stertor and jactitations, and it is for the prevention of these that the use of oxygen was first suggested.

Signs of Anaesthesia

With this mixture the signs of anaesthesia are quite distinct from the signs of nitrous oxide administered alone.

As the patient becomes unconscious the breathing becomes quieter and more regular, and at the same time

deeper than before. The loud stertor will not be heard, but in its place there will generally be noticed a faint snoring sound produced by the vibration of the soft palate, which is one of the best signs of unconsciousness. If after the patient has been inhaling gas and oxygen for some little time, and the breathing is deep and regular, but at the same time this snoring sound cannot be heard, it may often be obtained by turning the indicator back about four holes, and with this diminution in the amount of the oxygen inhaled, the faint snoring sound will generally be heard.

If the anaesthetist is not certain from these signs that the patient is ready for operation, he may also be guided by the following :

(1) In most cases, though not in all, the conjunctival reflex is absent when the patient is unconscious.

(2) The muscular system as a whole will be found relaxed, and if one of the patient's arms be lifted, and then let go, it will drop to the side. This is not always the case, however, and instead of this flaccidity of muscles there may be rigidity, which is more often noticed in alcoholic patients.

Advantages of the Addition of Oxygen to Nitrous Oxide

This mixture possesses advantages over pure nitrous oxide in the fact that the anaesthesia obtained with it is *longer*, and *quieter*. Speaking roughly, it is about half as long again. Hewitt, as a result of timing many cases with a metronome, found that the average time available for operation with gas and oxygen was 44 seconds, as compared with 30 seconds with pure nitrous oxide. The anaesthesia is *quieter*, for, as stated above, if oxygen has been admitted to the mixing chamber in suitable proportions there will be no stertor, but, what is of more practical importance to

the operator, instead of the jactitations, which are often a source of great inconvenience, there will be an absolutely tranquil sleep, generally with marked flaccidity of the muscles, and practically never accompanied with opisthotonus.

The addition of the oxygen renders the mixture a more suitable anaesthetic for young children, and old, or delicate people, as by its use the asphyxial element, which might prove harmful in many cases, is eliminated. When compared with its advantages, the *disadvantages* of the addition of oxygen to nitrous oxide are very small. With the use of the mixture the return to consciousness is not always so rapid, and it is more often accompanied by headache, giddiness, nausea, and even vomiting, than is nitrous oxide when administered alone.

An inexperienced anaesthetist may find some difficulty in using the apparatus at first; in fact, considerable practice is necessary before the mixture can be given with a uniformly good result.

The time required to produce anaesthesia with this mixture is longer than with gas alone. Hewitt, in his cases timed by a metronome, found that the average time taken with gas and oxygen was about 110 seconds, as compared with about 51 seconds with gas alone.

Of course, by this method, more nitrous oxide is used for each administration, than when it is given without oxygen or air.

Nitrous Oxide Mixed with Air

For the administration of nitrous oxide mixed with air the apparatus described above for the administration of pure nitrous oxide is the best. All the details of the preparation of the patient, etc., apply to this method, and with the following exceptions the administration should be carried out as if no air were being given.

After the patient has taken about six good breaths of nitrous oxide the lower slot should be opened by turning the handle, and one inspiration of air should be allowed. Then, after five or six more inspirations of gas, one more of air should be again given, and so on. It is impossible to state the definite proportions of air that should be given for any patient, but practice will soon show the anaesthetist what a valuable addition he has within easy reach. The amount of air required varies with the general condition of the patient, and the length of time required for the operation.

As regards the general condition, it may simply be stated that young children and anaemic girls require most air, and that strong alcoholic men should be given very little.

If the operation is to be very short it is not necessary to give much air, as the anaesthesia resulting from the inhalation of nitrous oxide without air might be enough; but in the writer's opinion it is well to give some air with every administration of nitrous oxide, for the sake of the quieter anaesthesia which will result.

Signs of Anaesthesia

If only one or two breaths of air are given the gas may be pushed till the signs of anaesthesia described under pure nitrous oxide begin to make their appearance—that is, slight stertor, cyanosis, and twitchings; and even then the resulting period of anaesthesia will be longer and quieter than if no air had been given.

If, however, more air has been given—in fact, enough to do away with all the asphyxial results of the gas—the usual signs will not be manifest; in other words, the patient will not become cyanosed, but will remain of a fairly good colour, and no stertor or jactitations will be noticed. Instead of the noisy breathing, the patient will now breathe

with long, deep, regular inspirations as if asleep, and instead of the loud stertor there may be generally heard a faint snoring, as in a typical case of anaesthesia by gas and oxygen, and this may even be quite absent.

After a little practice the anaesthetist will recognise this quiet, unconscious breathing, and when it is once present he may remove the face-piece and allow the operation to be begun. If, however, he is not sufficiently accustomed to the method to rely on the sound of the breathing alone, the administration may be continued till the conjunctival reflex is abolished.

By the allowance of a sufficient number of breaths of air an anaesthesia quite comparable with that of gas and oxygen may be obtained. It is as quiet, and lasts as long, and possesses the advantage of being obtained with a less complicated apparatus, and by the fact that after its use the return to consciousness is not accompanied by nausea or vomiting, as it is occasionally after the use of gas and oxygen. By thus regulating the amount of air an anaesthesia can be obtained resembling that by nitrous oxide alone, though quieter, or a longer and still quieter one like that resulting from nitrous oxide and oxygen.

Some anaesthetists allow a constant supply of air by leaving the lower slot of the gas stopcock a little open ; but of this method the writer has no experience.

Continuous Administration of Nitrous Oxide

For the performance of some dental operations the anaesthesia which can be obtained with any of the methods described above is too short. If the operation cannot be done in two parts, so that an interval of a day or so may elapse between the two administrations, a second administration of gas, or gas and oxygen, may be given as soon as the patient has recovered from the effects of the first, and the mouth is clear of blood. If the attempt to remove a

tooth fails entirely, and no blood be left in the patient's mouth, the face-piece may be reapplied before the patient has recovered from the first administration. Any second administration of gas given in either of these ways is liable to be followed by a bad recovery, with headache, giddiness, nausea, or even vomiting. It is unlikely to bring any credit to the anaesthetist, and should only be resorted to in very exceptional circumstances.

When an anaesthesia of two minutes is required, it can only be obtained by what may be described as the prolonged administration of gas, or by the addition of ether.

Gas may be given continuously by means of a tube leading from the gas-bag into the patient's mouth, after he has been anaesthetised in the usual way. It requires careful manipulation, and is liable to get in the way of the operator, and to blow the blood about in the mouth.

The continuous supply of gas is best given through the nose. Harvey Hilliard uses a soft gum elastic tube, which is passed into the nostril; but the apparatus generally employed was devised by Paterson.

It consists (Fig. 17) of two gas cylinders coupled together as for the use of Hewitt's apparatus, but the *gas-bag* (C) used in this method is of smaller size, as a positive pressure of gas is sometimes required, and this is more easily obtained with a small bag, and by this means less gas is wasted. The *stopcock* (B), which is attached to the gas-bag, is known as a two-way stopcock, for by turning it the gas is either retained in the bag, or allowed to pass on through the two tubes (E and E′) to the nose-piece (D). The *nose-piece* is made of aluminium, so as to be as light as possible, and is of such a shape as to fit over the end of the nose, while to make it approximate more accurately, round its edge is attached an air-cushion (F), as in the ordinary face-pieces.

For use with this apparatus there is also a special *mouth-piece* (G), with a valve which allows the passage

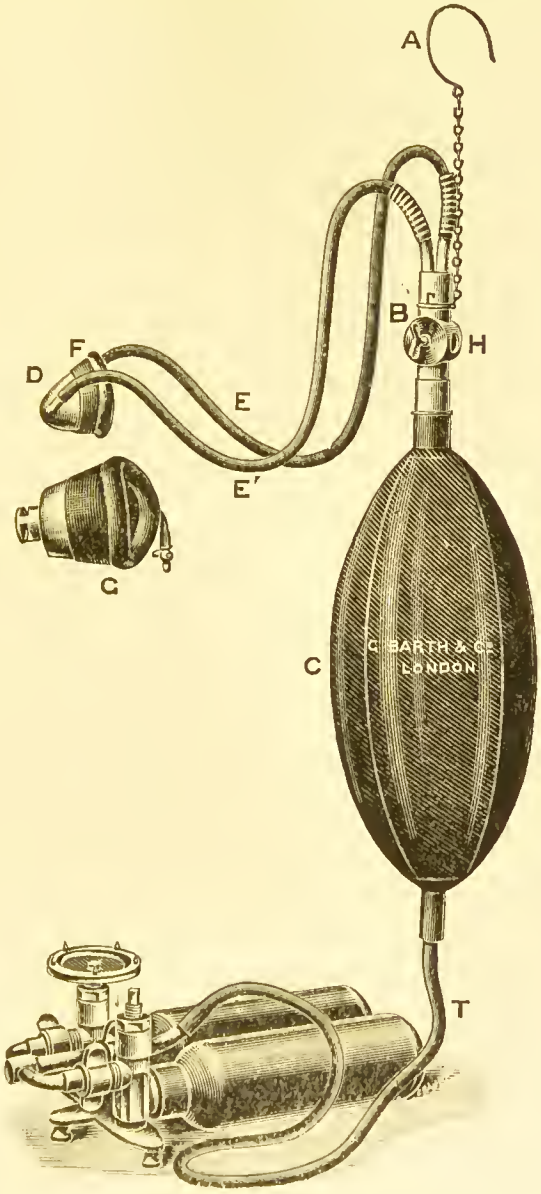

FIG. 17.—PATERSON'S APPARATUS FOR THE ADMINISTRATION OF NITROUS OXIDE BY THE NOSE

of expired air, but does not allow any air to be inspired through it.

The gas-bag should be easily visible to the administrator so that he may see the amount of distension of the bag, and for this purpose a hook (A) is fastened near the stopcock, so that the bag may be suspended from the back of the dental chair, or from the anaesthetist's coat, and thus be within easy reach for the purpose of turning the stopcock.

The Administration

The bag having been half filled with gas, the patient is seated as before described in the dental chair, and the prop inserted. He is instructed to breathe in through the nose, and out through the mouth. The nose-piece is adjusted to the nose and held in position by the fingers of the right hand, which rests lightly on the patient's forehead. The gas is now turned on by the rotation of the handle of the stopcock. As above mentioned, the bag should not be distended to its full extent at first, as if it is, the patient will feel the gas being blown through the nose, and this should be avoided. The mouth-piece should now be applied, and this will prevent any air being inspired, so the gas will be inhaled practically undiluted with air ; but this can be supplied as desired by the rotation of the stopcock, when the gas is cut off, and in its place air is admitted.

The amount of air allowed to each individual patient will vary, as does the amount of oxygen given with gas, or when air is given with gas in Hewitt's apparatus ; that is to say, more must be allowed to children and anaemic girls than to strong men, who will require little, if any. Speaking generally, phonation and movements indicate that more gas is required, while cyanosis and slight jactitations call for more air.

When air is to be given to the patient during the

administration it is best done by means of the stopcock, and not by tilting up the edge of the nose-piece. It is true that air may be admitted this way, but in doing so the gas is allowed to blow on to the face, and the nose-piece may not fit so well when it is replaced.

As soon as the breathing becomes deep and regular, and snoring is observed, the mouth-piece may be removed, and the operator allowed to begin his work. This may often be done after the patient has only taken five or six breaths. For children the bag should not be distended, but a positive pressure may be necessary in the case of vigorous men. If the patient breathe well from the start, the mouth-piece may be dispensed with, and gas will be inspired through the nose and expired through the mouth without any air being taken in through the mouth. When the patient is at all nervous, or does not inspire well through the nose as directed, or if the breath is held, or the respirations are very shallow, it is best to use the mouth-piece.

The administration of nitrous oxide in this way is remarkable for the short time which need be allowed to elapse between the turning on of the gas and the commencement of the operation, and also the ease with which patients will inspire through the nose, and then expire through the mouth, without taking in any air through the mouth, even when no mouth-piece is used.

The Operation

With this method the available anaesthesia is not to be counted by seconds, but by minutes; and the longest recorded time for which it has been employed is fifteen minutes.

During the operation the fingers of the right hand must keep the nose-piece in position, while the patient's head may be steadied by the pressure of the right wrist on his

forehead. With the left hand the stopcock may be turned to admit air when necessary; but when both hands are occupied, and air is required, the stopcock cannot be used, and air must be admitted by tilting the edge of the nose-piece with the right hand. When during the course of the operation the prop requires moving from the right side, the gag may be used with the left hand; and when the gag has to be used on the right side of the mouth, the nose-piece must be retained in position by the fingers of the left hand. This is not always easy, and a better plan is for the dentist to remove the prop when he has finished operating on the one side, and then place it in position for the operation on the other. There will be plenty of time for him to do this, and it makes the work of the anaesthetist much easier. It is this changing from side to side that constitutes one of the drawbacks to the administration of gas by this method for a long operation on teeth situated in different parts of the mouth. If an assistant is available, the changing of the prop for the gag, and the removal of the blood, which in the course of a long operation must collect in the mouth, may be left to him, and the burden of the anaesthetist will thus be lightened.

The most suitable operations for this method are those in which no change from side to side of the mouth is required, and where there is not much blood to be sponged away—as, for instance, the breaking up of the pulp of several teeth, or the extraction of nerves.

If the anaesthesia obtained by the administration of gas, or gas and oxygen, by any of the above methods is not sufficient for the operation in question, recourse must be had to gas followed by ether, which will be described on p. 144.

Nitrous oxide in some form is preferable, both on account of the unpleasant smell of ether, and the more severe after-effects which follow its inhalation.

Nitrous Oxide in Minor Surgery

Unless the operation to be performed requires a very short period of anaesthesia—that is, up to half a minute—nitrous oxide alone is unsuitable on account of the inconvenience caused by the jactitations which occur when the gas is pushed; but even with the anaesthesia obtained by giving the gas till slight jactitation appears, and then withdrawing it, a superficial abscess may be opened, or other trifling operations performed.

But for those operations which require a few minutes for their performance, a continuous administration of nitrous oxide mixed with air or oxygen will be quite satisfactory; though for the longer cases nitrous oxide with oxygen is the best.

If the operation is to be quite short, no more **preparation** of the patient will be necessary than that before the extraction of a tooth, but the longer the anaesthesia required, the more closely must the preparation of the patient resemble that of one who is to take chloroform or ether. (See p. 3.)

The chief **advantages** of nitrous oxide for minor surgical cases lie in the fact that it is quite pleasant to inhale, anaesthesia is soon obtained, and as a rule the recovery is rapid, and unaccompanied by unpleasant symptoms. Though in the majority of cases its action is so satisfactory, it must be remembered that the longer the operation lasts, the more likely is the recovery to be attended by headache, dizziness, vomiting, and collapse; and these may be sometimes as severe as those which follow the inhalation of one of the other general anaesthetics. A rapid return to consciousness is not always an unmixed blessing, for instead of remaining in a more or less dazed condition as after ether or chloroform, when sensation is not very acute, the patient may recover consciousness so rapidly that much more

of the after-pain of the operation is felt, and to counteract this morphia may be necessary, which is often undesirable. With nitrous oxide mixed with air or oxygen it is not always possible to obtain such a tranquil sleep as the surgeon may desire, and in some cases it is hard to obtain a thorough relaxation of muscles.

Cases suitable for Nitrous Oxide with Air or Oxygen

This anaesthetic should as a rule be reserved for operations that do not last more than about ten or fifteen minutes, for those in which complete relaxation of muscles is not required, and where the operation is not so delicate that a slight movement on the part of the patient would ruin it.

Many operations, too numerous to mention here, may be included in this category, such as opening and draining abscesses, scraping sinuses, moving stiff joints, removing ingrowing toe-nails, the first painful dressing after an operation, etc. Much more may of course be done if the surgeon makes all his preparations beforehand, and simply does that part of the operation which is painful while the patient is under the influence of the gas. For instance, for the performance of internal urethrotomy the guide may be passed before the patient is anaesthetised, and gas only given for the painful part, that is, the cutting of the stricture.

When a patient has to return home after a short operation, such as is performed in the consulting room, or the out-patient department of a hospital, there is on the whole no anaesthetic so suitable as nitrous oxide, mixed with air or oxygen.

The Administration

The apparatus is the same as that described above in the administration for dental cases.

If the gas is being given with air, the lower slot must be opened as often as is necessary to keep the patient a good colour.

With gas and oxygen the indicator must sometimes be turned to 10 to obtain the required amount of oxygen, and even that is sometimes insufficient, and the face-piece must be removed to allow of some air as well. To remedy this, an addition to the apparatus has been designed in which, by turning a screw, a quantity of oxygen equal to that obtained from 10 or 20 of the ordinary holes will at once be admitted to the mixing chamber, so that the proportion of oxygen may be increased to 30 per cent.

The patient may be sitting in a chair, or in almost any position that the surgeon desires, but the gas-bag should, if possible, hang freely, so that the amount of its distension may be easily seen. This is specially important if gas and oxygen is being administered, for the two bags must be kept equally distended.

To keep a patient in the exact condition which the surgeon desires for a quarter to half an hour often entails a heavy burden on the anaesthetist. It is easy to allow the patient too much, or too little, of the air or oxygen, and the mere mechanical labour of changing the cylinders, and turning on the gas is not inconsiderable. For an operation lasting half an hour, the amount of the gas used is about 100 gallons of nitrous oxide, and 15 gallons of oxygen, and the cost of this has sometimes to be considered, as well as the difficulty of the carriage of many heavy gas cylinders.

Whenever nitrous oxide is being given for a surgical operation, it is advisable that the apparatus for the administration of one or the other general anaesthetics should be at hand, in case a change becomes necessary from a failure in the supply of the nitrous oxide, or because the surgeon requires a more tranquil sleep.

If possible the change should be made to ether, on

account of its greater safety. Chloroform is more dangerous from the fact that the patient will probably be breathing deeply; and if the anaesthetist, in his anxiety to prevent an interval of consciousness, is too liberal in the supply of the drug, the patient will very probably receive an overdose.

The only case of death reported after the use of gas and oxygen is one of this sort, when it was found necessary to continue the anaesthesia which had been commenced with nitrous oxide and oxygen. Chloroform was employed, and the patient suddenly died.

Nitrous Oxide as a Preliminary to Ether

On account of the rapidity of its action, and its pleasant qualities, gas is frequently employed for the commencement of the administration of ether, and this will be fully described on p. 144.

It is unsuitable as a preliminary to chloroform, as with our present methods of administration of that drug the effects of the gas would have passed off before the chloroform could produce anaesthesia, and thus there would be an interval of more or less complete consciousness between the effects of the two drugs. In the administration of gas followed by ether there is no such gap, but the two gases are mixed together, and the anaesthesia obtained is continuous; but this "closed" method of inhalation is far too dangerous in the case of chloroform. Chloroform, too, if given from the first in a sufficiently diluted form, is generally so pleasant that gas is not required to disguise it.

CHAPTER IV

ETHYL CHLORIDE

Chloride of ethyl (C_2H_5Cl) was employed for general anaesthesia about fifty years ago ; but on account of the unsatisfactory symptoms which often accompanied its administration it was discontinued, and till the last few years was only used locally.

It was then discovered that many of the previous bad results were caused by impurities of manufacture, and since it has been prepared more carefully, its effects have been more satisfactory.

Ethyl chloride is a colourless liquid of a specific gravity of 0·920, and boils at 54·5 F. When it evaporates from blotting paper it should give off no unpleasant smell.

It is generally supplied in glass bottles containing 60 c.c. which are fitted with a metal stopcock, the liquid being obtained by pressing a spring. It is also supplied in glass capsules containing 3 or 5 c.c. The ethyl chloride for inhalation is labelled to distinguish it from that which is not so carefully prepared, and is intended for local analgesia. The recent revival of ethyl chloride as a general anaesthetic dates from 1901–2, when Rolland and Robinson demonstrated the advantages of a drug which they called "Somnoform." This is a mixture of 60 parts of ethyl chloride with 35 parts of methyl chloride, and 5 of ethyl bromide. This mixture easily decomposes and becomes unpleasant, from the evolution of free bromide, and,

together with "kelene," and other drugs which are principally composed of ethyl chloride, it has been abandoned for the pure chloride of ethyl.

Apparatus

The inhalers devised for the administration of ethyl chloride are almost innumerable, but all are of

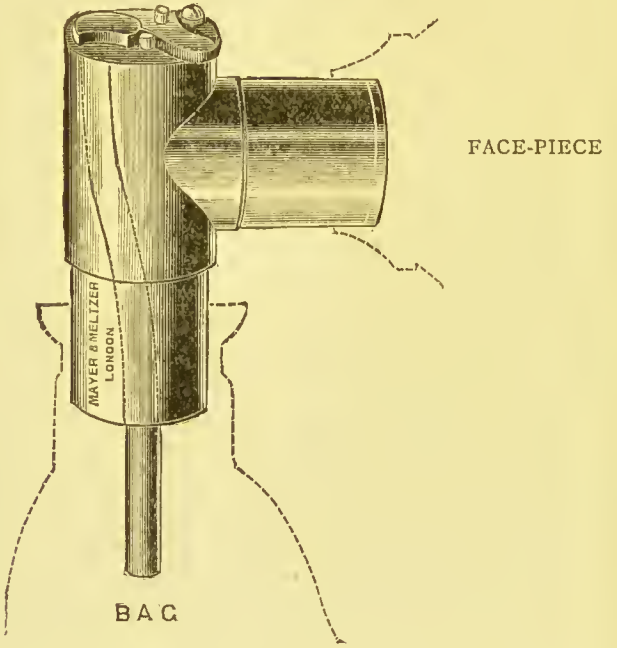

Fig. 18.—Angle-piece of Clover's Inhaler adapted for the Administration of Ethyl Chloride

the "closed" type, that is to say, they consist essentially of an india-rubber bag into which the patient breathes, and to which the ethyl chloride is conveyed by a more or less complicated stopcock.

They are unnecessary to a possessor of a Clover's inhaler, for the drug may be given in a perfectly satisfactory manner by using the bag and a suitable face-piece without

the ether chamber as is shown in Fig. 18. A hole is made in the metal angle-piece, sufficiently large to admit the stop-cock of the ethyl chloride bottle, and in the form illustrated this hole is automatically closed by a spring as soon as the bottle is removed. The liquid is conveyed to the interior of the bag by a small metal tube, so that none of it may be drawn into the mouth during inspiration.

Ormsby's inhaler for ether (p. 139) is quite suitable, and when this is used the nozzle of the ethyl chloride bottle should be pushed past the sponge, and the drug sprayed into the bag before the inhaler is applied to the patient's face. If there is an air-valve on the face-piece this should be open for one or two respirations and then closed. If a special inhaler is required, the "Simplex" inhaler, designed by Luke, is one of the best.

As re-breathing into the bag is allowed, the interior of the bag must be cleansed after each administration.

Some anaesthetists consider that re-breathing is partly responsible for the headache which is a common sequel, and have recently used a semi-closed inhaler, such as Rendle's mask for A.C.E. (p. 169). Larger doses of ethyl chloride are required, up to 7 or 8 c.c., but the results are said to be more satisfactory than when re-breathing is allowed. However, at present, a closed inhaler is generally employed, except when the patient is a small child, when a felt cone or a small Rendle mask should be used.

The Administration

When ethyl chloride is given for a dental operation or for the removal of tonsils, etc., the patient may be seated in a chair, and prepared as for the administration of nitrous oxide (p. 68).

If the bag of a Clover's inhaler is being used, or the "Simplex" inhaler, the patient's expiration should be caught in the bag till it is sufficiently distended, re-

breathing should be allowed for a few seconds, and then the ethyl chloride should be sprayed into the bag during an expiration, in order to avoid the possibility of the drug being drawn into the respiratory passages. Care should be taken to make the face-piece fit accurately.

For an ordinary dental operation a dose of 3 or 4 c.c. will be sufficient for an adult, and 2 c.c. for a child; but if a long anaesthesia is required, if the face-piece cannot be made to fit accurately, or if the patient is alcoholic, a further dose of 2 or 3 c.c. may be introduced into the bag.

The first few respirations are often shallow, but they soon become deeper and more noisy; and in from forty to fifty seconds loud snoring is generally heard. If the inhaler is now removed a quiet anaesthesia, lasting about a minute, will be obtained.

If the inhaler is not removed at this period, and if 4 or 5 c.c. of ethyl chloride have been given, an anaesthesia of two minutes may result. In this case the anaesthesia will be very deep, the corneal reflex absent, and the pupils widely dilated. The laryngeal reflex will also be abolished, so that this depth of anaesthesia is unsuitable for operations in the mouth, when there is a risk of blood entering the larynx.

It has been observed that anaesthesia frequently deepens after the removal of the inhaler, and this must be remembered, especially when the patient is a small child. Children are rendered unconscious with great rapidity, and if the inhaler is removed while they are still crying, a good anaesthesia will result; whereas if the inhaler is applied till they become quiet, the anaesthesia will often be too profound. The colour of a patient inhaling ethyl chloride is generally somewhat florid, and is in great contrast to that associated with nitrous oxide, when given without air or oxygen. No jactitations will be observed, but rigidity of muscles is not uncommon. This may

occur as opisthotonus, or in spasm of the muscles about the jaw, which is often very marked in men.

On account of the difficulty in opening the mouth from this cause care should be taken that a suitable prop is in good position before ethyl chloride is given for a dental, or other mouth operation, and some administrators insert a small prop whenever they use this drug.

Respiration is markedly stimulated, and there is no great change in arterial pressure when a small dose is given, and air is allowed as soon as anaesthesia is induced. But when a large dose is given, and air is excluded in the attempt to obtain a long period of anaesthesia, the arterial pressure may become lowered to a dangerous extent, and respiration may fail from this cause.

The return to consciousness is rapid, but it is not so satisfactory as that which follows nitrous oxide, for headache and giddiness are more frequent. Vomiting is more common, especially when the operation has been prolonged, and when blood has been swallowed.

The after-effects depend to a great extent on the preparation of the patient for the administration. When only a short anaesthesia is required nothing more may be necessary than is required before nitrous oxide ; but when the operation is expected to take a few minutes the patient should be prepared as for the administration of ether or chloroform.

Prolonged Administrations

Ethyl chloride may be administered for short operations of minor surgery by spraying additional doses into the bag as they become necessary. In this way anaesthesia sufficient for a major operation may also be obtained; but the longer the administration the fewer are the advantages that ethyl chloride possesses over ether and chloroform. For long operations preparation is essential,

and the return to consciousness becomes more prolonged, and is less satisfactory.

Special Uses of Ethyl Chloride

This drug should be considered as a substitute for nitrous oxide rather than a rival of ether or chloroform.

It presents advantages over nitrous oxide in its greater portability, and the simplicity of the apparatus required for its administration. The anaesthesia it obtains is more profound than that resulting from gas, and with a single dose, such as is required for operations in the mouth, as the removal of teeth, adenoids, tonsils, etc., it is also longer.

But it is not so safe an anaesthetic as gas, and unpleasant after-effects are more frequent. It is specially suitable as a substitute for nitrous oxide for the extraction of teeth, or removal of tonsils and adenoids in small children to whom it is difficult to administer gas. But the danger of deep anaesthesia in these patients must be borne in mind, and the entrance of blood into the larynx has several times necessitated tracheotomy. It is also of value for dental operations in alcoholic men.

Combinations with other Anaesthetics

Ethyl chloride may be used in combination with other anaesthetics. Thus 3 c.c. may be sprayed into the bag of an ether inhaler as a substitute for the preliminary dose of nitrous oxide.

It may also be sprayed on to the sponge of a Rendle's inhaler to shorten the induction period with A.C.E. mixture ; but this must be done with extreme care.

It is sometimes added to mixtures of ether and chloroform with the object of stimulating respiration.

Hewitt has suggested its use to prolong the anaesthesia of nitrous oxide in the following way :—

An ordinary bag is filled with gas, the tap at the lower

end is turned, and the bag detached. 5 c.c. of ethyl chloride are then sprayed into a glass tube, which is attached to the tap of the gas bag by a piece of rubber tubing.

The administration is begun by the patient breathing gas through the valves in the usual way for two or three inspirations, the tap of the stopcock is then turned and re-breathing into the bag is allowed.

The tap at the bottom of the bag is now turned, and the ethyl chloride poured into the bag by tilting the glass tube.

This is the most pleasant way of obtaining the longer anaesthesia of ethyl chloride for patients who recover consciousness too quickly when nitrous oxide is given in the usual way.

Relative Safety of Ethyl Chloride

This is still the subject of discussion, for though large numbers of successful cases have been recorded, it is also unfortunately true that many deaths have occurred. Many of these were caused by heart failure in patients distinctly unsuitable for the anaesthetic.

On the whole it may be said that ethyl chloride is not as safe as nitrous oxide, but is safer than chloroform ; but whether it is safer than ether or not, is hardly decided. This refers to its administration by those who have some experience of its use, for with the inexperienced anaesthetist ethyl chloride may become almost as dangerous as chloroform.

Danger generally threatens from the respiratory system, and a careless administrator may often have to perform artificial respiration ; but occasionally the heart seems to have been affected first. Ethyl chloride should never be given to patients suffering from heart disease, or those with much obstruction in their air passages.

CHAPTER V

ETHER: GAS AND ETHER

ETHER, ethylic ether, or di-ethyl oxide $(C_2H_5)_2O$, was formerly known as sulphuric ether, and must not be confounded with a substance called "compound anaesthetic ether," which is only intended for the production of local anaesthesia by cold. The ether which is used for inhalation is generally one of two varieties: (1) Aether purificatus (B.P.), of a specific gravity between 0·720 and 0·722, prepared from absolute ethylic alcohol. (2) Methylated ether, of specific gravity 0·720, prepared from methylated spirit.

These two varieties cannot be easily distinguished, but as that prepared from methylated spirit is about one-third the price of the aether purus prepared from absolute alcohol, this difference is well worth consideration, at any rate in hospital practice, where the drug is used in such large quantities.

At one time most administrators strongly advised the aether purus for anaesthetic purposes, as being less likely to contain impurities, and so to be attended with less secretion of mucus during its administration, and to be followed by a better recovery, with less nausea and vomiting. The methylated ether as procured from reliable chemists is, however, now so well prepared, that there is practically nothing to choose between the two.

Ether is a colourless, limpid, highly volatile liquid,

with a characteristic taste and smell. It does not mix freely with water, but does so with alcohol, chloroform, etc. Its vapour has a density of 2·58, is highly inflammable, and when mixed with air, it is explosive. Ether should never be poured from a bottle near any naked flame, as accidents have happened from this cause.

Its extreme volatility is one reason for the fact that ether is not often used in tropical climates ; but it may be given there quite well in a suitable inhaler. The india-rubber, however, of which many parts of the apparatus is made, quickly perishes in the heat, and it is for this reason that ether is so little used in hot climates.

Ether exposed to the air and light decomposes readily, and hence it should be stored in small bottles in a cool, dark cupboard. Ether which has been exposed to light and air, and therefore presumably containing impurities, may be purified by some metallic mercury being poured into the bottle, which is then shaken up, and allowed to stand. The impurities become deposited as a grey sediment, and the pure ether may then be decanted off. If a small quantity of the ether dropped on to blotting paper evaporates without leaving a greasy stain, and if no unpleasant and irritating smell is given off, it may be supposed that the drug is fairly pure ; but for all the tests that a good ether should stand, the reader is referred to the British Pharmacopœia.

The cases for which ether is suitable as an anaesthetic are discussed on p. 183.

Ether may be administered by one of two methods, which are respectively described as the " open," and the " closed."

By the open method the ether is given in an inhaler which admits of dilution with a large volume of air. It has not been employed much in this country, but lately it has been tried more frequently.

The usual apparatus is a wire mask known as Schimmelbusch's, and often used for the administration of chloroform, but for ether it is of a larger size. This is covered with ten or twelve layers of surgical gauze, on to which ether is dropped. A piece of lint, or some rolled gauze, is generally placed between the mask and the face.

In order to make the administration more pleasant, a few drops of chloroform or A.C.E. mixture are often given before the ether.

The advantage of this method consists in the absence of obstruction to respiration, such as may occur when a closed inhaler is used badly, and in consequence the patient's colour will be better, respiration will be quieter, and there is often little secretion of mucus and saliva. When ether is given in this way the risk of the patient receiving an overdose of the anaesthetic is small.

The open method has the disadvantage of requiring large quantities of ether, much of which escapes into the operating theatre, and may become a source of annoyance. The period of induction is prolonged, sometimes very considerably, especially in alcoholic patients. Coughing may be troublesome during induction; there also seems to be a greater risk of bronchitis following the administration.

This method has become a routine with some surgeons, especially in America and some parts of the Continent, and a preliminary hypodermic injection of $\frac{1}{6}$ of a grain of morphia with $\frac{1}{120}$ of a grain of atropine is often given half an hour before the administration.

When the use of ether with a free supply of air is indicated, a Rendle's mask for A.C.E., which forms a semi-open inhaler, is quite suitable; while for patients in a very serious condition, ether may be given from an ordinary Skinner's mask.

For the administration of ether to children a small felt cone with a piece of sponge pushed up to the apex forms a very good inhaler.

The essential feature in the **closed** method of administration is that the patient, instead of being supplied with a free amount of air, breathes backwards and forwards into an india-rubber bag, to which is attached a receptacle con-

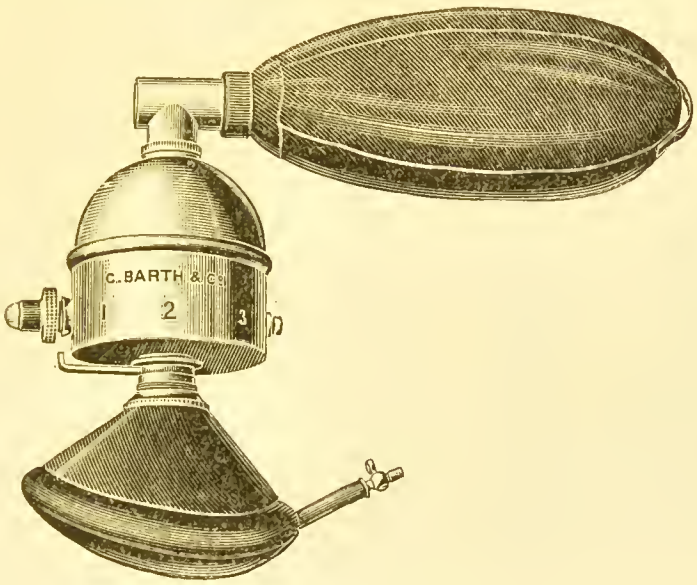

FIG. 19.—CLOVER'S INHALER

taining the ether. In this way the evaporation of large quantities of ether into the surrounding air is prevented, and there is less struggling and coughing. Unconsciousness is produced in a much shorter time, and the risk of the inhalation being followed by bronchitis is much diminished. In this re-breathing there is an element of asphyxiation, but as soon as the patient is unconscious air should be allowed in such quantity that the patient should suffer no harm from this cause. The risk of bronchitis is further lessened by the fact that the mixture which the patient

inspires from the bag will be at a higher temperature than the air which so freely dilutes the ether vapour when the "open" method is employed.

The Administration of Ether in a Closed Inhaler

The Apparatus

The inhaler generally used is known as Clover's small,

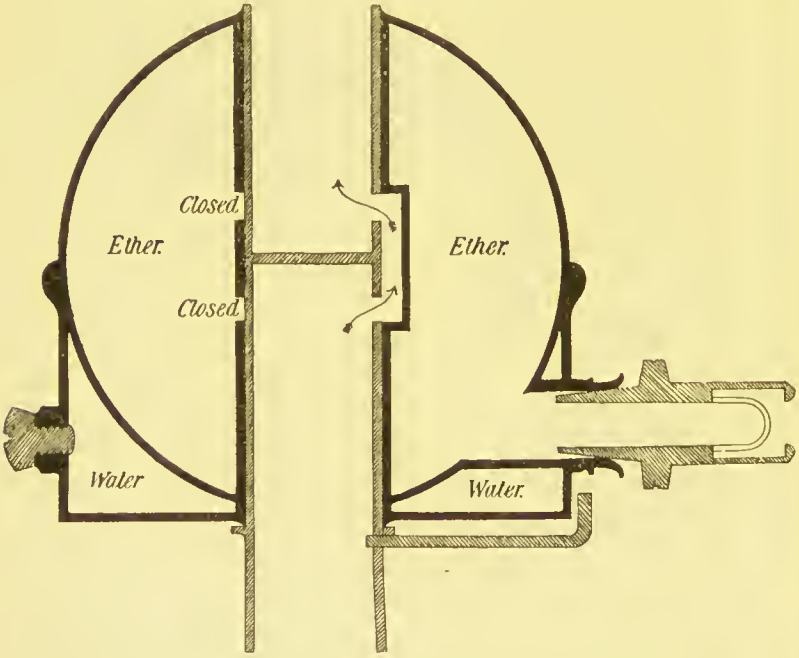

Fig. 20.—Section through Clover's Inhaler with Indicator at 0. All the breath is passing through the column, from the face-piece to the bag and back, without any entering the ether chamber

or portable, inhaler, to distinguish it from the larger and more cumbrous form, which is described in Dudley Buxton's "Anaesthetics."

The dome-shaped metal *inhaler* (Fig. 19) consists of a spherical chamber into which the ether is poured, and through which the breath circulates on its way to and from

the mouth to the bag. To the lower part of this sphere is attached a circular, flattened chamber containing water, which is added to produce a more equable evaporation of the ether.

The central part of the sphere is pierced by a shaft in which rotates a column, to which are attached both the face-piece, the bag of the inhaler, and the indicator. About

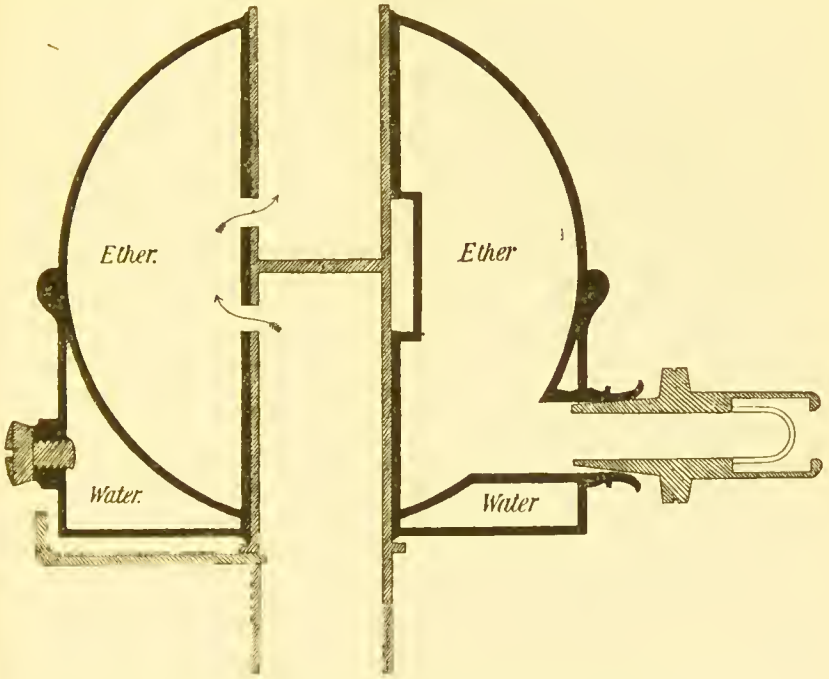

Fig. 21.—Section of Clover's Inhaler with Indicator at Full. All the breath is now passing into the ether chamber, and out again

the middle of this shaft there are openings into the ether chamber, and on the corresponding part of the column are also openings through which the breath may pass from the face-piece, through the column, to the interior of the ether chamber, and out again through the upper part of the column to the india-rubber *bag* at its extremity (see Figs. 20 and 21).

By means of the rotation of the ether chamber on the central column, more or less of the breath passes into the ether chamber in its passage from the face-piece to the bag, and back again. The proportion of the breath that thus passes into the ether chamber is regulated by the approximation of the holes in the central column with those into the chamber, and can be best understood by the actual examination of the apparatus, though the above diagrams may help to make things clear. The breath that does not enter into the ether chamber simply passes from the face-piece, through the column, to the bag, and back again. The proportion of the air respired that enters the ether chamber is indicated by the figures which are placed round the inhaler. Thus, when the indicator points to 0, none of the breath which is passing backwards and forwards from the patient's mouth to the bag is entering the ether chamber on its way. With the indicator at 1, one part of every four is circulating over the ether, while the other three parts are simply passing backwards and forwards as before. With the indicator at 2, two-fourths or one-half is entering the chamber; at 3, three-fourths; and at F, or "Full," all the breath is passing into the ether chamber on its way to and from the bag.

The *face-pieces* are the same as those used in the administration of nitrous oxide (p. 61), and various sizes must be at hand. When one is being adjusted it should be seen that the indicator of the inhaler fits accurately into the slot of the face-piece, as otherwise the heavy upper part of the inhaler is apt to fall off while the administration is in progress.

There have been many modifications of Clover's inhaler, and of these Hewitt's model with a large bore possesses a great advantage in the freedom with which the patient can respire through it. This can be appreciated by attaching a face-piece to each form, and breathing through them

alternately. With the larger bore it is easier to keep the patient's colour satisfactory, especially when he is alcoholic, and as a rule the amount of mucus and saliva secreted is less.

A free air-way is also provided in the simpler form of inhaler shown in Fig. 22. This differs somewhat from the Clover model.

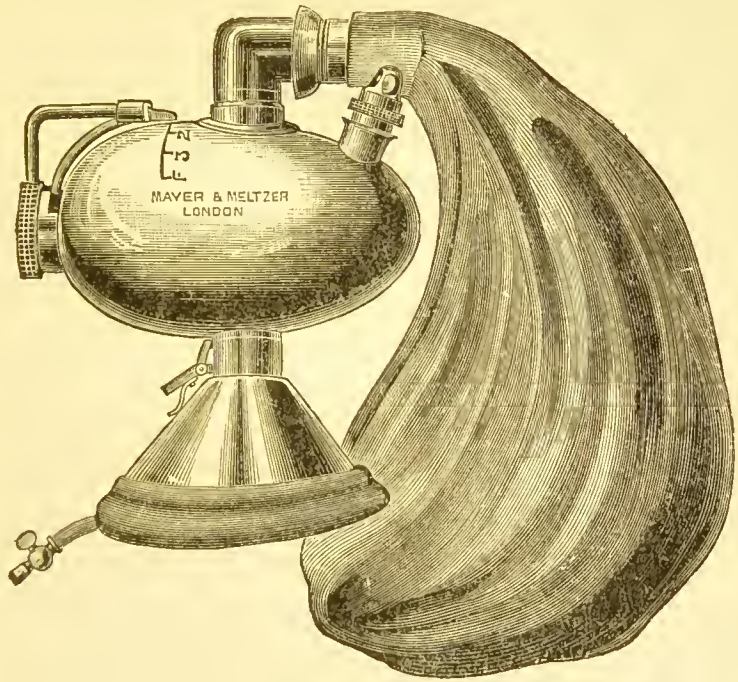

Fig. 22.—Probyn-Williams' Ether Inhaler

The body of the inhaler is pierced by two tubes, one vertical, the other horizontal. To the extremities of the vertical tube are attached the face-piece and bag respectively, and through this tube the patient breathes. In the horizontal, or long, axis there rotates a tube which regulates the proportion of the stream of air which is deflected into the ether chamber, as is shown in the diagrams (Figs. 23 and 24).

The indicator is attached to the extremity of the horizontal tube, and moves round part of the body of the inhaler.

The lumen of the vertical tube is that of an average adult trachea, and, as it is not contracted in any part, there is no obstruction to free respiration, as there is in all forms of Clover's inhaler. The openings into the ether chamber are of the same calibre as the vertical tube.

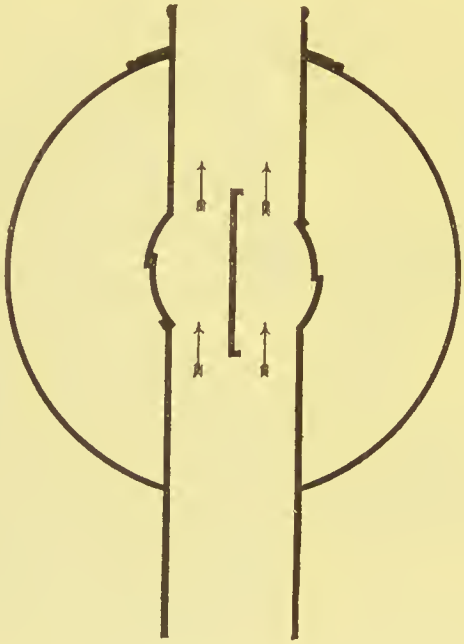

FIG. 23.—SECTION OF PROBYN-WILLIAMS' ETHER INHALER WITH INDICATOR AT 0

As there is no water-jacket, the inhaler may be sterilised by boiling; and after this has been done the regulating tube should be dried, and greased with vaseline before it is replaced in position.

The face-pieces are of metal with a rubber air-cushion, and can be readily placed in position, and maintained there by a simple catch. This is the lightest form of all regulating ether inhalers, and the most convenient to hold.

Ether may be preceded by nitrous oxide, as in Clover's inhaler, or by ethyl chloride by means of the angle-piece shown in Fig. 18.

Position of the Patient

As stated in Chapter I., the patient should, if possible, lie on his back, with his head turned to the right.

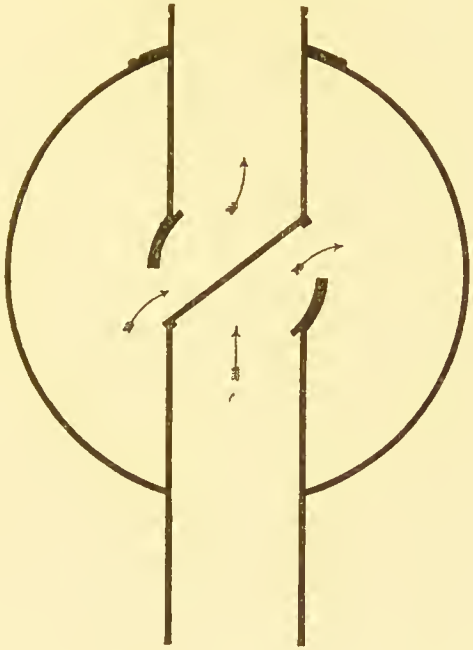

Fig. 24.—Section of Probyn-Williams' Ether Inhaler with Indicator at F

This will be the most convenient position for the administrator, and as a rule will not be uncomfortable for the patient. But, if the operation is to be performed on the right side of the face, head, neck, or shoulder, the head should be turned to the left, so that no mucus or saliva can contaminate the seat of operation. With the head turned to one side any mucus that may collect will tend to run into the cheek, and may then be removed. The

head should be supported on as many pillows as the patient requires, till consciousness is lost, when those that the administrator considers unnecessary may be removed.

Though during most operations under ether the patient is in the dorsal position, there is no reason to prevent its being administered to a patient sitting up in a chair, as there is in the case of chloroform.

The Administration

The usual examination of the patient, as described on p. 5, is now to be made, special care being taken to ascertain the presence of bronchitis or emphysema. If the patient has been lying on his back for some time, the bases of the lungs should be examined for signs of congestion.

The choice of the anaesthetic having fallen upon ether, a face-piece is selected which will best fit the patient, the air-cushion round its edge being distended.

In very cold weather the inhaler should be placed in some warm water for a few minutes before the ether is poured in, so that it may become warmed, and the rate of evaporation of the ether thus increased. The inhaler must not be made hot, and of course it must not be placed in warm water while any ether is in the chamber.

A measureful of ether, in quantity about one and a half to two ounces, is now poured out, and smelt by the administrator before it is poured into the inhaler. It is a good plan to smell the ether before it is poured into the inhaler, as occasionally the liquid in the bottle labelled ether has consisted for the most part of chloroform, and has been inhaled by the patient with a fatal result. The anaesthetist ought to suspect pure chloroform, if in an ether bottle, by its greater weight ; but a mixture of chloroform and ether has been detected by the fact that the anaesthetist has smelt the liquid before its introduction into

the inhaler, and in all probability the patient's life has been saved by this simple precaution.

Before any fresh ether is poured in, any that remains from a previous administration should first be removed and thrown away. Ether should only be poured into the chamber when the indicator is at 2. If this is done while the indicator is at 0, all the air that is displaced by the introduction of the ether must escape through the hole by which the ether is entering. In this way it will bubble up through the ether, some of which will be spilt on the floor, and the room filled with its pungent smell.

As soon as the ether is in the chamber, and the selected face-piece is fixed on, the anaesthetist should blow vigorously through the apparatus to get rid of the vapour which hangs about the central column. If the inhaler is placed on the patient's face before this is done, the strong smell of ether will disconcert him, and may make him cough.

The bag is now adjusted empty, and the patient is instructed to take a good breath, and then to blow out into the bag. The inhaler is held some little way from the face during inspiration, but should be closely approximated during the expiration, so that the bag may be distended with the patient's breath. Before applying the inhaler to the patient's face some administrators distend the bag with their own breath, but this practice is open to very obvious objections, and should always be avoided. Some anaesthetists let the patient breathe through the inhaler before adjusting the bag, but this is hardly necessary.

Holding the Inhaler

With the head turned, as suggested above, to the right side, the face-piece is held in the right hand in the position shown in Fig. 25. The thumb and forefinger are placed round the central part of the face-piece, while the weight

of the inhaler rests upon the back of the hand. When adjusted to the patient's face the thumb approximates the upper part of the face-piece, while the forefinger—or if necessary the first two fingers—maintain the lower part

FIG. 25.—METHOD OF APPLYING FACE-PIECE FOR THE ADMINISTRATION OF ETHER. The body of the inhaler, which has been omitted in the figure, rests on the back of the hand

of the face-piece in position. In this way two or three fingers are left free, and should be placed under the chin, where they will be of great assistance in keeping the jaw in good position. When the face-piece is removed for the patient to inspire air, these fingers may still remain under the chin, and in this way the jaw will be kept in good

position and an efficient air-way maintained. It is a common failing in the inexperienced anaesthetist to allow the jaw, and with it the tongue, to fall backwards when the patient is given a breath of air. By so doing the air-way is obstructed, the expected amount of air is not received by the patient, and a temporary asphyxia is produced. To remedy this the patient will often make a violent expiration resembling a cough, and this will often be a source of much inconvenience to the operator. In operations about the neck, too, the dropping back of the jaw, when control of it is abandoned by the anaesthetist, may completely alter the field of operation, and the partial asphyxia resulting from it will cause a venous engorgement of the part, which will further embarrass the surgeon. Thus it will be seen that the jaw should be kept in a suitable position when the patient is breathing air, as much as when he is breathing into the ether chamber, and if the inhaler is held in the way suggested, this good position is easily maintained by the help of the fingers under the chin.

If during a long operation the right hand becomes tired, and there is no reason to the contrary on account of the operation, the patient's head may be turned to the left, and the inhaler held for a time in the left hand.

As stated in the chapter on the administration of nitrous oxide, the face-piece will generally fit better if it is held lightly in position, without undue pressure. This applies equally to the administration of ether, and any pressure of the fingers or thumb on the sides of the face-piece will so elongate it, that the air will probably enter both at its upper and lower ends.

If the patient possesses a strong moustache it will cause less leakage of air if it can be tucked into the inside of the face-piece. A stiff beard will often render the exact fitting of a face-piece very difficult. It may give less trouble

if it is well rubbed with hot water, but even then some unavoidable leakage may take place; but as the administration proceeds it will become less resistant, and the face-piece will fit better.

The patient now breathes backwards and forwards into the bag, which should not decrease in size. If it does, the face-piece is probably not fitting well, and this must be remedied. When the face-piece is fitting well, and the patient is breathing freely, a distinct sound of the breath passing into the bag will be heard. This sound is not easily described in words, but when once heard can always be recognised, and, together with the distension of the bag remaining constant, constitutes a certain sign that the face-piece is fitting well, and that the patient is breathing satisfactorily.

When the patient has respired into the bag five or six times the ether may gradually be turned on by rotation of the ether chamber, so that the part marked from 0 to 1 is passed over the indicator, which remains stationary. This movement should be very gradual, and cannot be too slow at first. If it is done too quickly, the patient will be made very conscious of the presence of the ether, and will either hold his breath or cough; whereas if it has been slow and gradual, he will become drowsy, and will not notice the gradually increasing strength of the ether. As long as the breathing continues regular, without any coughing, the ether may be steadily turned on; but if the breath is held, the inhaler should be kept applied to the face with the indicator at the same place, till the breathing is again fairly regular. If coughing occurs, it is better to turn back to a weaker proportion of ether till tolerance is established, when a stronger proportion should be gradually given again. Coughing will often be noticed in men who are heavy smokers. It may sometimes be overcome in this way by giving a more dilute proportion

of the ether for a short time ; but if it persists, the opposite plan must be tried, and the ether pushed so that the coughing reflex is abolished. Occasionally ether may be found so irritating, that the anaesthetic must be changed to chloroform or one of its mixtures, though if a little A.C.E. be given till the coughing reflex has disappeared, ether can then be administered again with good results.

By the time that the indicator is opposite 1, the ether may be turned on more quickly, but still gradually, so that the patient is not made to cough by the suddenness of the increase in the strength of the vapour. In this way in strong men the indicator may mark " full " before the patient is unconscious. In small children it is not necessary to go beyond 1½, or beyond 3 for women. In fact, the figure to which the indicator is rotated varies with different administrators ; some anaesthetise their patients by allowing them to breathe for a long time a dilute vapour, while others soon render them unconscious by quickly increasing the strength of the ether. The mean between these two courses is probably the best, that is, to reserve " full " for vigorous men, especially if alcoholic, and in the case of most women not to advance beyond 3, nor beyond 2 in the case of children. As the patient becomes unconscious a change will be noticed in his breathing, which becomes more regular, and deeper. At this stage, too, many of the muscles become relaxed, and the administrator must see that the jaw is in a good position. While the patient is conscious it is unnecessary, and annoying to him, for the jaw to be violently pushed forward ; but as soon as he begins to lose control of the muscles which prevent it from slipping back, the administrator must assist him.

To keep the jaw forward—and with it the tongue, in order to maintain a good air-way—one of the fingers of the left hand is placed behind the left angle of the jaw, and pressure is exerted in the direction of the mouth.

If the inhaler is held in the way suggested on p. 124, much assistance will be derived from the fingers placed under the chin. If firm pressure does not seem to affect the position of the jaw, the inhaler should be removed for a moment to see if the lower teeth are caught behind projecting upper teeth, and, if so, the jaw must be depressed, and an attempt made to get the lower teeth in front of the upper ones. It occasionally happens that the tongue becomes caught between the front teeth, and if this is discovered it must of course be remedied.

With the jaw in good position, and the air-way clear, the breathing gradually becomes deeper. If there is cyanosis, a breath of air should be allowed by removing the inhaler for one inspiration, care being taken to re-apply it during expiration, so that the bag is kept distended. Care must also be taken that the face-piece fits as well as it did before it was removed. Much air should not be given till the patient is really anaesthetised, as in this way the ether becomes too much diluted, and acts as a stimulant, exciting the patient, who then probably struggles violently. This withholding of air during the induction is one of the features of the "closed" method of the administration of ether, but air must be given when the patient requires it, as will be shown by the colour of the face and the ears. Another sign that calls for air is a slight clonic movement of the arms or shoulders. This is not often seen, but when it does occur, the inhaler must be removed for two or three breaths, as the movement is probably asphyxial in origin, and is comparable to the jactitations seen in anaesthesia with pure nitrous oxide gas.

Signs of Anaesthesia

When the breathing has become deep and regular, the administrator seeks for further signs of unconsciousness. The upper eyelid should be gently raised with a forefinger.

If any resistance to this is noticed, it is certain that the corneal reflex is also present ; but if no resistance is felt, the corneal reflex should next be tried. To do this, while the upper lid is raised with the forefinger, the cornea is gently touched with the tip of another finger. If the reflex is present, some movement will be seen or felt in one or other of the lids. If there is no movement, the patient may be considered anaesthetised, and ready for most operations. For some operations, however, it is not sufficient to stop short at this stage, but the ether must be pushed till the muscles at the seat of the operation are relaxed. For instance, in abdominal sections, operations for the cure of hernia, etc., the abdominal muscles must be relaxed before the operator can proceed.

As soon as the corneal reflex is lost, the patient may be allowed a breath or two of air, and the inhaler should then be replaced with the indicator opposite a lower figure. For instance, supposing that the patient is a strong man, and that when the corneal reflex was found to have disappeared the indicator was at "full," after a breath or two the inhaler should be replaced with the indicator at 2. If necessary for the further relaxation of muscles, or on account of the return of the corneal reflex, the strength of the ether may be again increased. In a similar manner the strength of the ether vapour should be decreased in all classes of patients when once the corneal reflex has disappeared.

The average time required to produce anaesthesia with ether in a Clover's inhaler is about five minutes. Much depends whether the patient breathes freely from the first, and whether much struggling occurs. With a well-fitting face-piece there should be little struggling if the ether is turned on very slowly and gradually, especially at first ; but if this is not done, and the patient inhales a strong ether vapour while quite conscious, coughing and struggling

will almost certainly result, and the time required for the production of the anaesthesia will be much increased. It has been pointed out above that holding the patient down, re-arranging blankets, dressings, etc., may cause struggling.

If struggling does occur, the patient may be best kept on the operating table by pressure on both shoulders and above both knees, while a hand should press on the forehead. In this way no damage is likely to be done, but care must be taken in superintending over-zealous assistants. During his struggles the patient sometimes tries to remove his face from the inhaler, or to pull the inhaler away, and this must be if possible prevented, and the face-piece kept as well applied as the circumstances will permit, for the struggling will probably be stopped more quickly by an increased strength of ether, than by a further admixture with air.

It is when struggling occurs that one of the great advantages of ether over chloroform is shown in the lesser tendency to syncope which accompanies the use of the former anaesthetic.

Refilling the Bag

The bag must never be allowed to become empty, so that the sides are sucked together during inspiration; but if during the course of the administration it becomes less and less distended, it must be refilled by removing the inhaler to allow the patient to inspire air, and then quickly replacing it and catching the expired air in the bag.

When ether is being given to a patient lying almost prone it is very difficult to keep the inhaler properly adjusted to the face. To remedy this the late Dr. Sheppard suggested a short tube, bent at a right angle, which is inserted between the face-piece and the ether chamber, as shown in Fig. 26. By the use of this tube the face-piece can be made to fit accurately, while the rest of the

apparatus will be kept clear of the pillows on which the patient is lying.

Regulation of the Anaesthesia

The patient being anaesthetised, and ready for the operation, the administrator is now concerned with the proper maintenance of the anaesthesia, and must work by the signs enumerated on p. 17, viz. the presence

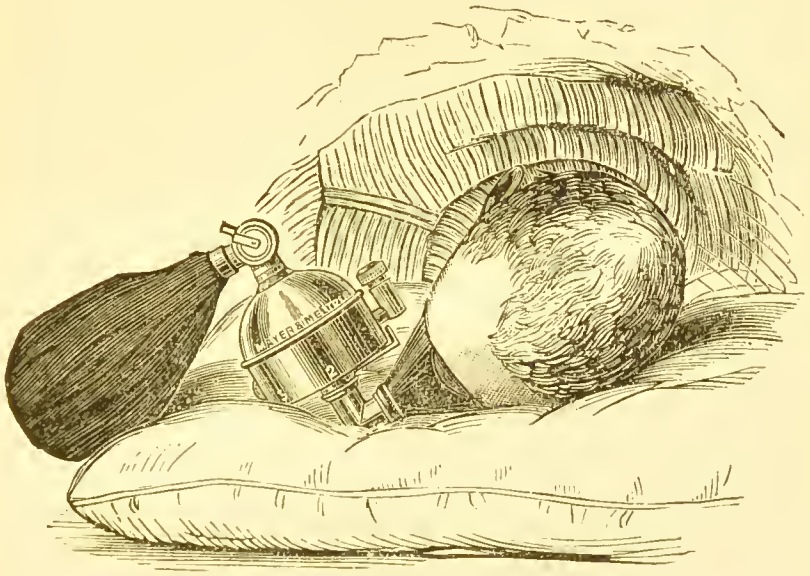

Fig. 26.—Sheppard's Angular Adjuster

of the corneal reflex, the size of the pupils, the rhythm of the respiration, the character of the pulse, the colour of the face, and muscular movements.

In all important operations, especially those on the abdomen or other vital parts, the *corneal reflex* should not be allowed to return ; but in operations on the limbs, where the part is steadied by an assistant, and a slight movement would not ruin the operation, the reflex may be allowed to reappear, and to be present for most of the

period of anaesthesia. Of course, the mere presence of the reflex does not affect the surgeon, but, if the reflex is present, the next sign of the light anaesthesia may be straining, or actual vomiting, and by either of these the operation might be spoilt. In testing for the reflex it is best to try both eyes alternately, as by the frequent touching of one cornea it may become less sensitive, and conjunctivitis may also be set up.

The *size of the pupils* is a very useful guide as to the depth of the anaesthesia. When the corneal reflex is first lost they will probably be somewhat dilated from muscular exertion, and partly from the amount of ether that has been given, but also from the limitation of oxygen which is unavoidable in the production of unconsciousness by the closed method. As air is given, however, the pupil soon becomes smaller, and the average size of the pupil of a patient well under ether is 4 mm. in diameter, though this is perhaps rather a high estimate. If the pupil become larger, the cause must be sought and remedied, as described in the general consideration of the anaesthetic state (p. 21).

The *respirations* should now be deep and regular, as shown by the regular distension of the bag, and the sound of the breath passing into it. By constant practice the administrator can work almost entirely by the respiration—that is to say, he can give just the right amount of ether to keep the patient in a most satisfactory condition through listening to every respiration. He will learn to appreciate all the small variations in rhythm and quality; but this only comes from constant practice, and he must carefully watch all the other signs that can give him any assistance, especially the colour of the face. If the respirations which were previously deep and regular suddenly stop, and the breath is "held," the corneal reflex will probably be present; in other words, the anaesthesia has been allowed to become too light, and more ether must be given. This

may often be noticed when the first incision is made in a patient who is not sufficiently under. Another cause for this sudden alteration in the depth and regularity of the respirations is the slipping back of the jaw when the pressure behind the angle is relaxed, and by this, of course, the air-way is obstructed.

The respirations may keep perfectly regular, and yet the bag may not distend so well as it had previously been doing. This is probably due to some change in the position of the face-piece, which does not now fit so accurately as before.

If the respirations, though still keeping regular in rhythm, become faster and more shallow, the ether has probably been given too freely, and more air should be allowed. If the deep respiration to which one is so accustomed in the administration of ether becomes unduly quiet, the cause will be one of two : either the ether has been given too sparingly, and with too free an admixture of air, or an overdose of the ether is being administered. In the first place, the corneal reflex will be present, and the pupil will either be the dilated pupil of reflex dilation, or the very small, almost pin-point, pupil which is the precursor of vomiting. If this be the case, the ether must be given more freely. In the second case, when the respiration becomes quiet, with a dilated pupil and no corneal reflex, the ether has been pushed too far, and the inhaler must be withdrawn, and more air allowed.

Though it is necessary to listen to every respiration, it is quite unnecessary to keep a finger on the *pulse* throughout the administration. Ether has been described as having a large " manageable zone," and before the circulation becomes at all embarrassed there will be other signs of distress, as shown by the alterations in the respiration, the colour of the face, etc. If these are attended to there is practically no fear of trouble arising from the circulatory

system while ether is being administered; and even if the respiration stops from any cause, the pulse will probably be found to be still fairly good, and if the respiration can be restored, the patient has a very good chance of recovery. This is in striking contrast with the behaviour of the circulatory system under chloroform. Still, though a finger need not be kept on the pulse, it should be frequently examined, as it gives the most reliable signs of the effect of the operation on the patient. The pulse, which was previously full, regular, and of moderate rate, may become smaller, and faster, and perhaps irregular. This may be because too much ether is being given, or because the patient is suffering from the general effects of the operation; in other words, from "shock," or haemorrhage, or the two causes combined. If the pulse is deteriorating from an overdose of the anaesthetic, it will improve rapidly when more air is allowed, but this recovery will not take place if it is due to the general condition of the patient. If the inhaler is held as suggested on p. 124, it will be convenient to examine the pulse in the facial artery as it crosses the lower jaw with the left index finger.

When the corneal reflex is lost for the first time the *colour* of the patient will probably be somewhat cyanotic, on account of the limitation in the supply of oxygen, but it should rapidly improve when air is allowed. It is a mistake to suppose that the normal colour of a patient under ether should resemble that of one under pure nitrous oxide, and cyanosis should never be allowed to remain. If the colour does not improve when the inhaler is removed, and air allowed to be respired, the fault may lie in the partial obstruction of the air-way. The causes of this are fully discussed on p. 36. When all attempts to remedy this cyanosis by the removal of all obvious obstruction, and the admission of air, have failed, improvement may be effected by the substitution of an Ormsby's inhaler for the Clover

apparatus. As will be described later, the former apparatus has a larger bore, and so presents less obstruction to respiration, and when the patient requires a large amount of ether, this change to the Ormsby's inhaler may be very satisfactory.

The colour may be improved by removing the bag of the inhaler, thus converting the " closed " apparatus into one more or less " open." In this case it is generally better to move the indicator to a higher figure.

Some anaesthetists have sought to overcome this tendency to cyanosis by the administration of oxygen with the ether. This may be done by changing the small bag of the Clover inhaler for the large bag used for gas (p. 61), with the slots of the stopcock closed so that the valves are out of action. The oxygen may be allowed to flow into the bag by the usual entrance for the gas, and the patient now respires his own breath, mixed with ether vapour, and with oxygen in any required proportion. A tap is sometimes fitted to the ordinary small bag, and oxygen supplied through a tube attached to it.

No attempt will here be made to describe any of the special apparatus for the administration of oxygen with ether, for if the cyanosis is so marked that oxygen is required to lessen it, the better plan would be to give ether by the " open " method, or to change to A.C.E., or chloroform.

To maintain a patient in a satisfactory condition, as shown by the above signs, it will not be necessary to keep the indicator at a higher figure than 2, even for the strongest man, when once he has been anaesthetised. For weaker men, and for women, the indicator should remain at $1\frac{1}{2}$, while for small children 1 will be found quite sufficient.

When the corneal reflex is first lost, the inhaler should be removed for one breath in every four or five for the admission of air. This proportion may be maintained

for some minutes, and then air may be allowed more frequently, the colour of the face being a very good index to the amount required. Weak patients and women may require more, and of course little children want much more. As the operation proceeds the amount of air allowed must be increased, and the amount of the ether administered lessened. It is often necessary to point out to students that in the administration of an anaesthetic the object in view is not to see how much a patient may inhale with safety, but to administer the smallest amount that will produce the required results.

"Ether Rash" and "Ether Tremor"

These two phenomena are more or less peculiar to anaesthesia with ether.

The **ether rash** may occur in any patient, though it is more common in women and children than in men. It appears as a rule just as the patient is becoming unconscious, and takes the form of an erythema, which occurs most frequently on the neck and shoulders, but may spread to the chest and abdomen, and even to the thighs and legs. It may be accompanied with profuse sweating, and generally lasts for less than ten minutes. When seen for the first time, it suggests to the uninitiated measles or scarlet fever.

The **ether tremor** is a clonic contraction of the muscles of the legs, though those of the thigh may also be affected, and rarely the movement may occur in the muscles of the upper extremities. It is met with most frequently in healthy young men who are imperfectly anaesthetised—that is to say, either as they are going under, or coming round from the anaesthetic. As the movement will probably cause the operator inconvenience, it should be stopped by giving more ether till a deeper degree of anaesthesia is obtained.

Replenishing the Ether

In the newer forms of the Clover's inhaler the stopper which closes the hole through which the ether is added to the chamber terminates in a glass bulb. The amount of the unevaporated ether can be estimated by noticing the angle to which the inhaler must be tilted, before any of the liquid is seen to run into the glass.

If the patient be a man, the first measureful will be almost exhausted by the time that he is well under the influence of the anaesthetic; at any rate, it is as well to pour a fresh measureful in before the operation is begun. This one will probably last for a quarter of an hour, the third measureful for from 20 to 25 minutes, and so on, less and less being required as the operation proceeds.

In pouring fresh ether into the chamber, the inhaler should be first removed from the patient's face, and rotated till the indicator is opposite 2. The stopper is now removed, the ether poured in, and the stopper replaced; but before the inhaler is reapplied to the patient's face, the indicator should be turned back to 1. The reason for this is that while the inhaler is removed from the face for the introduction of the fresh ether, the patient has been breathing air alone, and the strength of the vapour which he was inspiring before this may now be too much for him, and he may be inclined to cough from the increased proportion of the ether. After one or two breaths have been taken with the indicator at 1, it may be turned on to the figure it was at before the inhaler was removed.

If there is no glass bulb at its extremity, the stopper itself may be removed, and the amount of ether in the chamber seen by the tilting of the inhaler. A rough idea of the amount present may be obtained by feeling the uppermost part of the ether chamber, and then comparing it with the lowermost. If there is ether in it, the lower

part will feel colder to the touch, from the evaporation taking place inside, but this test is not very delicate.

Care of the Apparatus

After use, the face-piece should first be removed, and all mucus, etc., washed away. The bag should be half filled with a weak solution of carbolic acid (1 in 60-80), well washed round, then emptied, and left to dry, suspended by the small india-rubber loop attached for the purpose.

The stopper should be removed from the inhaler, and, with the indicator at 2, all the ether left in should be poured away. The central tube should then be removed from the body of the inhaler, washed, and dried.

The body of the inhaler may now be immersed in warm water, and left there for a few minutes, but the water should not be too hot. When the body of the inhaler has been dried, the central tube should be greased with a little vaseline, and replaced. If care is not taken, the central tube will become rusty, and the body of the inhaler will only turn with difficulty. The ether chamber often contains a greenish coating, which is best removed by absolute alcohol.

Administration of Ether with Ormsby's Inhaler

Ormsby's inhaler, of which there are now many modifications, is of much simpler construction than Clover's. It consists essentially (Fig. 27) of a cage made of wire to hold a sponge, on to which the ether is poured. To one end of this cage is attached a large india-rubber bag, into which the patient breathes, and which makes the administration "closed" in character, and to the other end is attached a metal face-piece, with an air-cushion round its edges so that it may fit the face of the patient.

This is the simplest form of the apparatus, but many additions to it have been made. Among these are a

hot-water chamber, to prevent the sponge becoming frozen from the rapid evaporation of the ether ; an opening in the face-piece by which air may be admitted in varying proportions ; and there are many variations in the size of the bag, etc.

The Administration

The sponge, having been wrung out of hot water, is squeezed dry and replaced in the cage, and on to it is

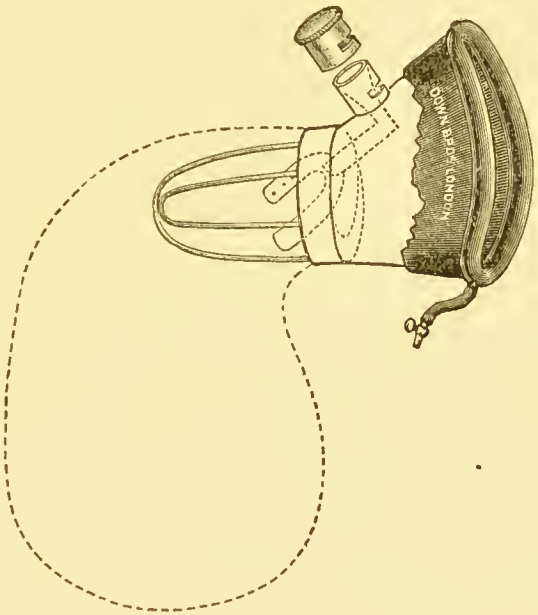

Fig. 27.—Ormsby's Inhaler

poured about half an ounce of ether. The inhaler is now gradually placed nearer and nearer to the face of the patient, who is encouraged to breathe as freely as possible. If there is an air-slot in the face-piece it should be open at first, till the patient becomes accustomed to breathing into the inhaler. When once the patient can tolerate the ether, the inhaler is made to fit as well as possible,

so that the bag may remain distended. If it becomes emptied, it should be filled in a way similar to the bag of the Clover apparatus, by removing the inhaler during inspiration, and replacing it during expiration.

However well the anaesthetic may be administered with this apparatus, the patient must receive a fairly strong ether vapour from the first, and will most probably cough or struggle, unless the ether is preceded by nitrous oxide.

As long as there is any ether vapour left in the bag, its presence may be detected by the two surfaces of the bag moving freely over each other when rubbed between the fingers ; if the bag is empty, this movement will be accompanied with much more friction, which can be easily appreciated by the fingers. When the ether is exhausted, the inhaler should be removed from the face, and about half an ounce more of ether poured upon the sponge. If the sponge freezes, it should be replaced by another which has been wrung out of hot water, and the same amount of ether should be poured upon it.

The *disadvantage* of the Ormsby inhaler is that with it the strength of the ether vapour cannot be regulated with any precision, and hence it is not suitable for the beginning of an administration. But if the ether is preceded by nitrous oxide this objection vanishes, and the inhaler is very useful.

It presents a great *advantage* over the Clover in the fact that the part through which the patient has to breathe is larger, and so respiration is more free ; and also that with it a greater strength of ether vapour can be given, which is much wanted in the case of alcoholic men. The student, however, is advised to practice thoroughly with a Clover before trying the Ormsby, as it is much better to learn the capabilities of one apparatus before giving it up for another ; and with a little trouble, ether can be

administered by means of a Clover's inhaler to any patient for whom it is a suitable anaesthetic.

The Ormsby inhaler is also suitable for the administration of ethyl chloride (p. 107).

The Administration of Ether to Children

For little **children** ether is very conveniently given in a small felt cone with a piece of sponge at the apex, or even with the Skinner's mask generally used for chloroform. The administration will be more pleasant if a few drops of the A.C.E. mixture are poured on the sponge first, and pure ether substituted later. Care must be taken that the sponge and the cone are not saturated, or liquid ether will run on to the patient's face.

If Clover's inhaler is used for small children, a concave face-piece will be found useful.

Special Difficulties and Dangers connected with the Administration of Ether

These generally arise in connection with the respiratory system, and troubles due primarily to the circulatory system are rare.

Syncope under ether is practically unknown, and if in the course of a long operation the pulse fails, it is in almost all instances due to surgical shock, or to loss of blood. In patients with very degenerate arteries the inhalation of ether has been followed by cerebral haemorrhage, but this accident is fortunately rare.

The principal difficulty during the administration of ether is the maintenance of a good air-way. The causes of this have been fully discussed (p. 125), and here it need only be mentioned that the actual causes which tend to obstruct the breathing with ether are the narrowing of the air-way from congestion, especially when the ether is badly given, and sufficient air is not

allowed to the patient, the accumulation of large quantities of mucus, and the difficulty in keeping the jaw in position, on account of muscular spasm. All these causes, which obstruct the air-way, make themselves known by the bad colour of the face; and the bag will not distend as it should under normal conditions.

An excessive *secretion of mucus* is one of the drawbacks to ether. Though in many instances, especially during short operations, it is of small consequence, yet in others it is of such importance that it necessitates a change in the anaesthetic. If the head is well turned to one side, the mucus and saliva will tend to collect in the cheek rather than pass backwards and obstruct the air-way, and if a corner of a towel or a piece of lint be placed in the dependent cheek, much of it may in this way be absorbed. Sometimes, however, in spite of all precautions, it collects in such large quantities that the mouth must be opened, and the mucus removed with a sponge. If this is neglected, it may be sucked back during inspiration, and, combined with what is already present in the larynx, may prove a formidable obstruction to respiration. When mucus reaccumulates after the pharynx has been sponged out, it is wiser, when the operation has to be continued for some time longer, to change the anaesthetic for the A.C.E. mixture, or even pure chloroform.

Besides this accumulation of mucus in the mouth and pharynx, there may be a hypersecretion throughout the respiratory tract which is made obvious by rattling sounds heard in the trachea, and if these are noticed the ether should certainly be discontinued.

Mucus in the pharynx and upper air-passages is generally removed by the first act of vomiting, or when the patient becomes conscious and coughs. But this is not always the case; for instance, in operations on the abdomen, where the patient is probably feeble and lying on his back,

or when the operation has been on some part of the chest, which is in consequence tightly constricted with bandages, this removal by coughing is not at all easy, and the mucus either remains as a source of irritation, or the patient is worried by ineffectual attempts to remove it. Mucus is also said to form a favourable resting-place for the pneumococcus. In any of these operations it is better to change the anaesthetic on the earliest signs of an undue secretion of mucus.

Spasm of the larynx is also met with more frequently with ether than with chloroform (p. 36).

There may be considerable difficulty with young men in keeping the lower jaw sufficiently forward, especially during the earlier stages of the operation. The finger must be placed behind the angle, and pressure exerted in the direction of the mouth, while all possible help should be given by the fingers under the chin. If the skin is tender, part of the towel should be placed between it and the finger, so that there will be less risk of bruising. Fortunately, as the operation proceeds, the pressure necessary to keep the jaw forward becomes less, as the resisting muscles gradually relax.

Signs of an Overdose of Ether

When ether has been given too freely, and the patient is in the fourth stage of narcosis, the face becomes dusky and cyanotic, the pupils are dilated and fixed, the eyelids separated, and the corneal reflex entirely absent. Respiration may at first be rapid and shallow, but afterwards becomes slower and quieter, and then intermittent, with jerky or gasping inspirations. When this condition is first noticed there may not be much change observable in the pulse, but if the condition is neglected, the circulation will fail, and the pulse become faster and smaller.

When the signs above enumerated are noticed, the

inhaler must at once be removed, and air allowed, and if the respiration is failing, it must be aided artificially (p. 45). If necessary, it may be stimulated by a hypodermic injection of strychnine.

If these measures are taken promptly the patient will recover in almost every instance.

After-Treatment

It is most important that all patients who have been inhaling ether for some time should be kept in a well-warmed room till their recovery is complete, on account of the risk of bronchitis and broncho-pneumonia.

Before the complete return to consciousness there is often a single act of vomiting, which removes the mucus which has accumulated. The patient as a rule does not remember this, and if food is not given too soon, this is often the only after-effect, with the exception of the smell and taste of the ether. The smell may be mitigated by soaking a handkerchief in toilet vinegar and suspending it near the head; and some patients disguise the taste by sucking peppermints, or small pieces of lemon.

Ether preceded by Nitrous Oxide—Gas and Ether

The great advantage of this combination is that the patient is rendered unconscious by gas, without experiencing the unpleasant smell of ether; and in consequence there is less struggling, and anaesthesia is produced more quickly.

There are two ways in which gas and ether may be given.

First, or Clover's Method

By starting the administration with gas, and, as soon as the patient is unconscious, gradually giving ether in increasing strength.

This can be better done with a Clover's inhaler than with Ormsby's, as with it the strength of the ether can be more gradually increased. The Clover inhaler should

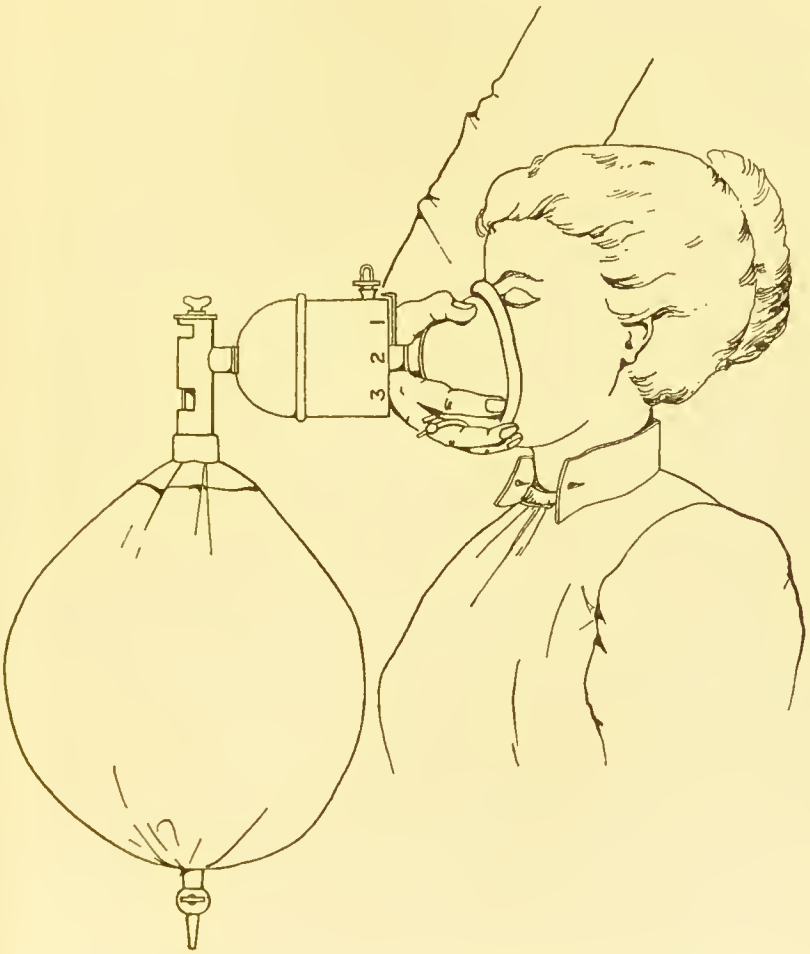

Fig. 28.—The Administration of Gas and Ether with Clover's Apparatus to a Patient sitting upright

first be prepared as for ether alone (p. 122). The gas-bag (p. 61) should now be filled, the tap at the lower end turned, and the bag detached from the tube. It should now be

attached to the ether inhaler in the same way as the small bag is for ether alone, and the anaesthetist should blow through the face-piece to remove all traces of the ether, and to see that all the valves are working.

The inhaler is now to be applied to the patient's face, and he is allowed to breathe a few times through the valves. The gas is turned on by closing the lower slot, and should be expired through the valve till the bag is only half full. The upper slot is now closed by the tap, so that the patient is " rebreathing " into the bag.

After a few more breaths the ether is gradually turned on by rotating the inhaler, and this may be done more rapidly than when ether is given without gas. When the indicator has reached 2, the large bag may be removed, and the small bag adjusted in its place, and this will be used for the rest of the administration.

The administration now proceeds exactly as with ether alone, except that it will probably be necessary to give some air earlier.

The above way is the best for giving gas and ether for a dental operation, as the quantity of ether administered can be more easily regulated. It may safely be administered to a patient sitting upright in a chair, as in Fig. 28.

Second, or Braine's Method

By giving gas till the patient is fully under its influence, as shown by slight jactitations, and then giving a full strength of ether vapour.

The Ormsby inhaler is more satisfactory for this method, as the respiration through it is less obstructed, and a stronger vapour can be given ; but Clover's inhaler may be used with the indicator at " full."

Gas is first given in the usual way till the patient is anaesthetised, and there are signs of commencing

jactitation. The gas apparatus is now removed, and an Ormsby inhaler, already charged with ether, is quickly applied in its place, so that no air is allowed during the change, and the administration proceeds as if ether had been given from the beginning.

This second method has some advantage over the former in the case of strong alcoholic men, but the student is advised to become accustomed to the Clover method before using the Ormsby, as it is more generally useful.

With Braine's method there is more often some spasm of the glottis, from the inhalation of a full strength of ether vapour before sufficient gas has been given. If the gas has been pushed too far, the breathing may be temporarily stopped. In either of these cases the patient may become so blue that air must be allowed. If too much air is given, he may pass into a stage of semi-anaesthesia, the effects of the gas passing off before the ether has had time to become absorbed in sufficient quantity. This is more likely to happen than with the more gradual administration with Clover's inhaler.

Ether may also be preceded by chloroform or A.C.E., the inhaler being substituted as soon as the patient becomes drowsy. It is often preceded by ethyl chloride, 3 or 4 c.c. being sprayed into the bag of the Clover or Ormsby inhaler.

Ether may be administered by the rectum, as described in Dudley Buxton's "Anaesthetics."

CHAPTER VI

CHLOROFORM

CHLOROFORM ($CHCl_3$) is a colourless liquid, with a faint, characteristic smell, and a sweet, burning taste.

The pure chloroform of the British Pharmacopœia contains some absolute alcohol, which is added to make it less liable to decomposition, and its specific gravity after the addition of the alcohol is between 1·490 and 1·495. Its vapour density is over 4.

For the preparation of chloroform, and an account of its chief impurities and their detection, the student is referred to the British Pharmacopœia ; but if it evaporates without residue, and without giving off any unpleasant odour, it is probably fit for anaesthetic purposes. Two kinds of chloroform were till lately used for inhalation: the pure chloroform, which is made from alcohol, and what is known as " methylated chloroform," which is made from methylated spirit. But the cheaper form of chloroform is now generally prepared from acetone, and it is extremely difficult to recognise one form from another, if they are properly prepared, either by chemical tests, or by actual trial as anaesthetic agents. It has been stated that the chloroform made from acetone is improved by the addition of 0·25 per cent. of ethyl chloride.

Chloroform is very liable to decomposition from exposure to heat and light, and so should be kept in a cool, dark cupboard. It is much better to obtain it in small bottles,

than to have a large quantity exposed to the risks of decomposition. But if some slaked lime be kept at the bottom of the stock bottle of chloroform, any impurities resulting from decomposition will be neutralised, and the pure liquid when required may be decanted. The vapour of chloroform is not inflammable, but if much of the anaesthetic is allowed to evaporate in a room lighted by gas or any other naked flame, the vapour decomposes, and carbonyl chloride, and hydrochloric acid are formed, which are peculiarly irritating to the respiratory tract. During a long operation under these circumstances both the surgeon and nurses assisting have been known to suffer from cough and headache, and afterwards from bronchitis, from the irritation produced by these products of decomposition. A feeling of faintness may also be experienced, but this may be due to the amount of chloroform vapour in the air. Chloroform is twice as heavy as ether, and so can be easily distinguished from it by this means, as well as by the great difference in smell. It is a much more powerful drug than ether, for to anaesthetise a patient with ether about 40 per cent. of the vapour is required, while dangerous symptoms may arise if the proportion of chloroform vapour in the respired air reaches a higher percentage than 4. It thus follows that in the administration of chloroform, instead of trying to confine the vapour in a closed inhaler, as in the case of ether, the object of the anaesthetist is to make sure that the patient is allowed enough air to produce the required dilution.

Lister proved that the proportion of chloroform breathed by a patient inhaling the drug from a towel wet with chloroform, and held in front of the face, was considerably less than might be expected, and generally not more than 4 per cent., most of the chloroform evaporating into the air, or being blown away by the expirations. But if the access of air is cut off the proportion soon increases, and it was

shown by Sansom that it could reach as high a proportion as 13 per cent., which would soon prove too strong. Hence it follows that if the drug is administered by what is called the " open " method—that is, sprinkled on lint or flannel, or even the corner of a towel—all may go well if the supply of air is sufficient, but if this is unduly curtailed, the result may be fatal.

Apparatus for the Administration of Chloroform

The apparatus required for the " open " method is very simple. The inhaler may consist of a small piece of lint,

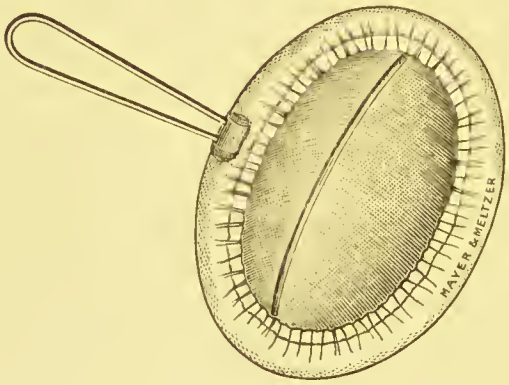

Fig. 29.—Skinner's Mask

or the corner of a towel. If the towel is employed, the best way is to draw one corner of it through a safety pin till a small concave mask is formed, which will extend from the bridge of the patient's nose to the point of the chin. If lint is used it should be folded into ridges, and these secured at one end by a safety pin. In using either of these simple inhalers it is important to watch that its concavity is maintained throughout the administration, as if it is allowed to lie flat on the mouth and nose it will obstruct respiration, the percentage of the chloroform will

become too high, and, if the patient survive, his face will be burnt.

The best form of inhaler is Skinner's mask, in which lint or flannel is stretched over a wire frame (Fig. 29). When not in use it may be folded flat, it is very light, and the handle at the side is most useful for holding the mask. The covering usually consists of a single layer of flannel,

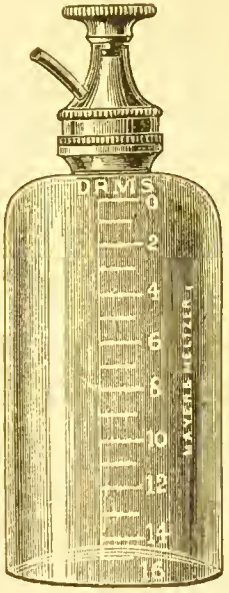

FIG. 30.—THOMAS' DROP-BOTTLE

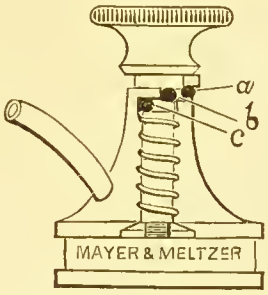

FIG. 31.—SECTION OF STOPPER OF DROP-BOTTLE. With the pin at *a* no chloroform can escape, at *b* it will fall out in drops as the stopper is pressed, while, if fixed at *c*, the chloroform will run out in a steady stream.

which is removed after each administration, and the whole may be sterilised. In hot climates a double layer of flannel is sometimes used. When this mask is used properly the flannel is kept so far from the skin that there is little risk of burning the face unless the administrator is careless. In Schimmelbusch's mask the frame is covered with lint, which is burnt after the administration.

The chloroform is dropped upon the mask from a drop-bottle, the best of which is known as Thomas' spring

drop-bottle (see Figs. 30 and 31). In the stopper is a spring which allows the liquid to come out only drop by drop, as the administrator presses the stopper, or it may be allowed to run out in a minute stream, or if turned in the opposite direction no chloroform can escape, and the bottle can be carried without leakage.

When chloroform is given by the "open" method a careful and experienced administrator will obtain an even anaesthesia, while one who is inexperienced or careless may produce a very irregular anaesthesia, in which at one moment the patient may be too lightly anaesthetised, and at the next may be suffering from an overdose.

The percentage breathed by the patient depends on the amount of air which the anaesthetist allows. If this supply is sufficiently free, all may be well; but the safety of the patient lies in the hands of the administrator more in the case of chloroform than with any other anaesthetic.

Many forms of apparatus have been devised to obtain a regular proportion of chloroform vapour. Junker's inhaler (Fig. 32) is the one most generally employed. The chloroform is contained in a bottle, and, by means of bellows, air is pumped through it, and then conveyed to the patient by a tube. By this means a fairly constant stream of vapour may be obtained, varying in strength according to the vigour of the pumping, but probably never exceeding 4 per cent.

The tube from the bellows has been accidentally attached to the wrong tube on the bottle, and liquid chloroform has been blown into the patient's mouth, with a fatal result. To obviate this, Hewitt has designed a modification in which the tube conveying the vapour to the patient is placed inside a larger one, by which the air is pumped into the bottle containing the chloroform, and in this way it is impossible for the tubes to be misplaced.

The bottle should never contain more than an ounce of

chloroform, and the apparatus should always be tested before use.

When Junker's inhaler is used for the induction of anaesthesia a face-piece is necessary, either one made of vulcanite, as in the original pattern, or of flannel stretched over a wire frame, or, what is better, the mask

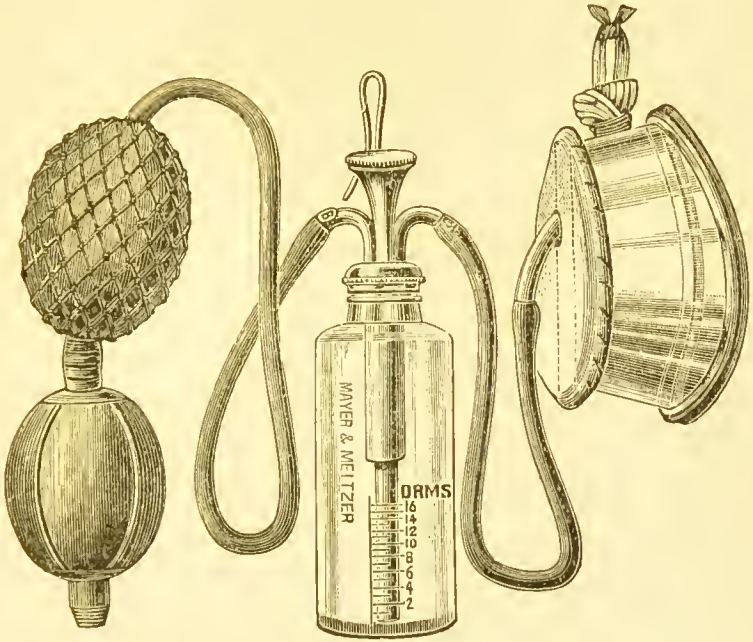

Fig. 32.—Dudley Buxton's Modified Junker's Inhaler with Glass Face-Piece

shown in Fig. 32. It is made of glass or celluloid, and has a piece of lint stretched across its upper part. This mask approximately fits the face from the bridge of the nose to the chin. This lint is changed after each administration.

When a patient is being anaesthetised with this apparatus it is sometimes found that the vapour which is pumped through the tube is not sufficient, and then more chloroform is given by dropping some of the liquid on to the lint. This will be often necessary in the case of alcoholic patients.

This may also be done with a flannel face-piece, but would be impossible with a vulcanite one. Through the sides of the mask the colour of the lips can be seen, and the whole apparatus can be kept perfectly clean.

A face-piece has been designed with a feather at the apex, which moves with respiration, but the feather moves so readily that the anaesthetist may be lulled into a false sense of security when in reality very little respiration is taking place.

When using Junker's inhaler the strength of the vapour may be to some extent regulated by the vigour and frequency of the compression of the ball of the bellows. The maximum strength is said to be obtained with about sixteen firm compressions in a minute.

An attempt has been made to regulate the amount of chloroform vapour pumped into the mask by means of a graduated ball and a mechanical pumping arrangement; but, however accurate an apparatus may be made, the safety of the patient will depend on the skill and carefulness of the administrator, rather than on the perfect working of any mechanical contrivance.

When an operation is to be performed inside the mouth the patient may be anaesthetised in the ordinary way with ether or chloroform, but the anaesthesia must be maintained by means of chloroform pumped by a Junker's inhaler through the nose or into the mouth. This may be done by attaching a soft rubber catheter to the end of the tube coming from the Junker bottle, and then passing it through one nostril till it reaches the post-nasal space. The catheter must not be pushed beyond this, as if it is it will be caught by the superior constrictor of the pharynx, and the chloroform would then be pumped towards the stomach instead of the lungs, and the presence of the catheter in the pharynx would probably set up vomiting in a patient not deeply anaesthetised. Instead of a nasal

tube the chloroform vapour may be conveyed to the mouth by a soft metal tube, which is hooked round the cheek.

As during the operation the mouth will generally have to be kept open, it will be found most convenient to attach the tube of the Junker's inhaler to one of the arms of the gag, as in Figs. 33 and 38.

It is better to use the tube attached to the arm of the gag which rests against the upper jaw, for the orifice on the lower arm is often blocked by the tongue coming in contact with it.

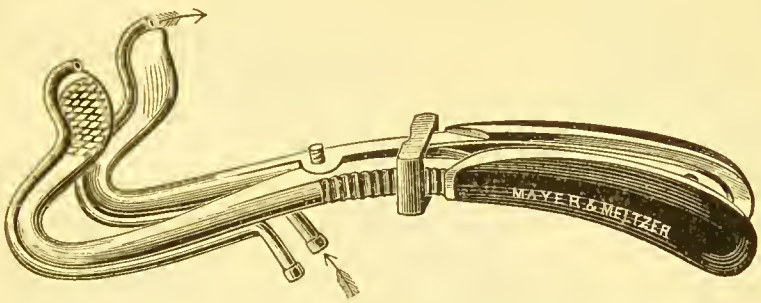

Fig. 33.—Mason's Gag with Hewitt's Chloroform Tubes

The chloroform tube in the gag shown in Fig. 33 is very narrow, and it is difficult to keep the inside of it clean. The tube on the gag in Fig. 38 is larger, and so allows a greater stream of chloroform vapour, and is quite easily cleaned; but as the gag is intended to rest on the incisor teeth, it may be inconvenient in some operations. Hewitt has suggested a tube ending in a metal prop such as used in dental operations.

In some extensive operations in the mouth, such as the removal of cancerous growths from the back of the pharynx, tracheotomy is first performed, and then chloroform is administered through the tracheotomy tube. Blood is prevented from entering the trachea by packing the

pharynx with sponges, or by means of a small bladder round the tracheotomy tube, which is inflated (Trendelenburg's Tampon), or by a sponge round the tube which absorbs the blood till it swells, and so blocks the trachea

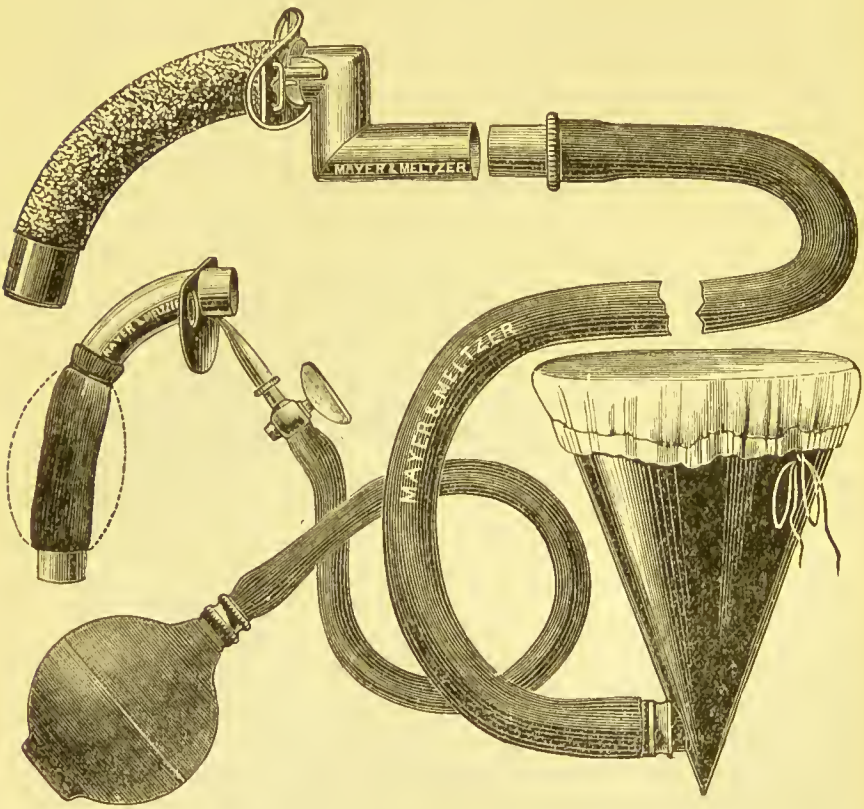

FIG. 34.—APPARATUS FOR ADMINISTERING CHLOROFORM AFTER TRACHEOTOMY. The upper tube with sponge is known as Hahn's, the lower, with a bag which is inflated with air, is Trendelenburg's.

(Hahn's Tube, Fig. 34). Chloroform is administered by means of an ordinary Skinner's mask held near the orifice of the tube; but to the orifice of the cannula a tube is sometimes fitted, of some two feet in length, and terminating at its other extremity is a small metal drum, over the

upper part of which some flannel or domette is stretched, and on to this the chloroform is dropped. This tube enables the anaesthetist to stand further away from the patient's head, and so allows more room for the surgeon.

Several inhalers have recently been designed in which

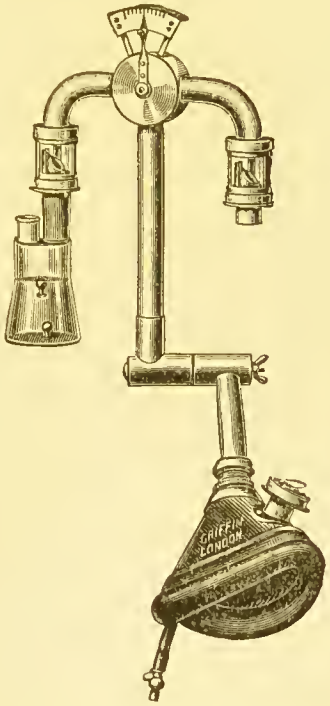

Fig. 35.—Vernon Harcourt's Chloroform Inhaler

the strength of the chloroform vapour inhaled by the patient is accurately determined.

The one most commonly used was suggested by Vernon Harcourt (Fig. 35). It consists essentially of a T-shaped tube, through which respiration takes place, with a face-piece, containing a valve for expiration, fixed at its base. To the extremity of one of the horizontal arms is attached a glass bottle with two necks, which is

half filled with chloroform. When inspiration takes place air is drawn over the chloroform, and a definite quantity of chloroform vapour is taken up. Air alone is admitted through the other horizontal arm, and mixes with the air containing the chloroform vapour in the circular chamber at the junction of the three arms. In this way a definite proportion of chloroform vapour, varying from 0·2 per cent. to 2 per cent., can be given to the patient, and the actual strength will be marked by the indicator.

If the face-piece does not fit accurately, and air is admitted round its edges, the percentage marked on the indicator is, of course, incorrect; and it is also incorrect if the chloroform is not kept at a suitable temperature, which is shown to the administrator by an ingenious use of coloured beads, which rise or sink according to variations in its temperature.

The apparatus can be held in one hand, be suspended round the neck, or be fixed to a stand, in which case an extra tube will be used to connect the face-piece with the base of the T-tube.

In administering chloroform with this inhaler, it must first be seen that the face-piece fits accurately, and if this is difficult a towel folded round it will prevent too much air entering round the edges. The indicator is first placed at 0, and then gradually moved on towards 2 per cent., the strength of the chloroform vapour being thus increased on general principles.

If 2 per cent. is found to be insufficient to produce anaesthesia, a metal tube may be placed in the neck of the chloroform bottle through which air is inspired, when a vapour of 2·5 per cent. or 3 per cent. may be obtained. When anaesthesia is obtained the indicator should be turned back; and it is surprising to find how small a percentage of chloroform is necessary to maintain anaesthesia in many patients, some requiring no more than 0·5 per cent.

If required, oxygen may be administered through the T-tube in place of air.

Full instructions for the use of this inhaler are supplied by the makers, Messrs. Griffin.

Cases Suitable for Chloroform

The cases specially suitable for the inhalation of chloroform are considered more in detail in Chapter VIII.

They are, in brief, persons at the extremes of life, young children and old people ; those with bronchitis, or marked emphysema ; cases of operation on the brain, or about the face, especially if a cautery is to be used ; for some abdominal operations ; when a light degree of anaesthesia is to be maintained, as in parturition; and to quiet the muscular spasm in tetanus.

The Administration of Chloroform

Chloroform is administered on the same general principles, whether it be given on a piece of lint, the corner of a towel, or with a complicated apparatus.

It is most important that the patient should be in the *recumbent position.* The use of the upright position for a patient inhaling chloroform cannot be too strongly condemned ; and it is in a great measure due to the neglect of this precaution that the deaths from chloroform are still far too numerous. Many deaths have occurred in dental chairs, where, besides the faulty position, the risk is increased by the administrator being often not very skilled in this branch of practice.

The head should be turned to the right, as in the administration of ether, and there should be no constriction of the neck, chest, or abdomen by tight clothing.

In giving chloroform by the " open " method, two or three drops of the drug are first poured on to the lint or flannel, which is held some three or four inches or more

away from the patient's face till confidence is to some extent established, and he begins to breathe regularly, when the mask should gradually be brought nearer the face. It is a great mistake to give a strong dose of the anaesthetic with the first few inspirations. A patient already nervous will become extremely frightened, and will probably struggle; and even when he has made up his mind to take the drug calmly, his equanimity will be upset by inhaling a strong dose of chloroform with the first breath. After beginning very gradually, the amount should be steadily increased, provided that respiration is satisfactory, till the area of the mask opposite the mouth and nose may, if necessary, be kept moist with the drug.

Chloroform should never be poured on to the mask in such quantities that it drops off the flannel and burns the face. This burning of the face is more likely to occur if the chloroform is given from a folded piece of lint, and to prevent this, the face is sometimes smeared with vaseline before the administration is begun.

The breath is sometimes held for a few seconds. This often occurs when the patient is struggling, or vomiting is imminent.

When the breath is held the mask should be withdrawn, and the lips rubbed with a towel till respiration begins again, when the mask should be replaced, and the administration continued. It is most dangerous at this time to pour chloroform on the mask, and hold it close to the face; for after the breath has been held the first inspiration is generally deep, and a fatal dose may be absorbed.

If the patient vomits, the mouth must be cleared of all vomited material before the administration is continued, for if any were allowed to remain, it might be sucked back into the larynx with the first vigorous inspiration.

Some patients require a large amount of chloroform to

procure anaesthesia, but on no account must the supply of air be restricted.

Respiration must be watched most carefully. Each expiration should be either heard or felt by the anaesthetist by means of fingers placed near the face. It is not enough that a small amount of respiratory movement is seen in the chest and abdomen, for this may occur when very little air is passing to and from the chest. If all administrators consistently watched every respiration, deaths from chloroform would soon diminish.

It is not necessary to keep a finger on an artery throughout the administration, but the pulse should be frequently examined.

If the chloroform be given too sparingly, the patient may pass into a quiet sleep, from which he will waken with a start when the operation is begun. This "false anaesthesia," or sleep, is more often noticed in the case of children, especially infants. In adults the corneal reflex will be present if the patient is not really anaesthetised, but in infants this sign is unreliable, as movement will often occur when the corneal reflex cannot be obtained, and pinching the skin is probably the most useful test of anaesthesia.

The **time** required to anaesthetise a patient with chloroform varies from five to ten minutes. It depends, in the main, on the regularity and depth of the respirations, with the rate at which the drug is poured on to the mask, and with the amount of struggling exhibited.

The **dose** which different patients require varies even more considerably than the time required to produce unconsciousness, and alcoholic patients may inhale a dose which would be enormous for most persons without exhibiting any signs of anaesthesia beyond muttering or singing. Children often seem to require more in

proportion to their size than do adults, but this is probably due to the small amount which they receive with each inspiration.

In certain cases oxygen may be administered with advantage in combination with chloroform. No special apparatus is necessary, but a small stream of oxygen may be given by attaching the tube from the oxygen cylinder to a metal tube, such as is used for giving chloroform by the mouth with a Junker's inhaler.

General Condition of a Patient under the Influence of Chloroform

The general signs of anaesthesia are those given in the first chapter, but with chloroform respiration will be found much quieter than with ether: in fact, it sometimes becomes almost inaudible, and if this happens, care must be taken to watch that the patient does not come round.

There is no excessive secretion of mucus, such as occurs with ether, but though there may apparently be little trouble arising from the respiratory system, it is just as important that the jaw should be kept in good position, and a clear air-way maintained.

If the jaw is allowed to slip too far back, the difference will be shown not so much by the increased noise of the respirations, as commonly happens with ether, but rather by a gradual change in the colour of the patient, and by a distinct weakening of the circulation, as shown by the greater frequency and smaller volume of the pulse. If the patient is breathing very quietly, but is otherwise in a satisfactory condition, the jaw may be allowed to slip back just sufficiently far to enable the administrator to hear a faint snoring sound with respiration. If this can be done without any change for the worse in the colour of the patient, or in the character of his pulse, it will be of

assistance to the administrator in enabling him to be accurate in estimating any change in the respiration of the patient; but if this produces any change for the worse in the general condition of the patient, the jaw must be pushed forward again to its full extent.

If the surgeon is allowed to begin the operation before the patient is in a sufficiently deep stage of anaesthesia, a crowing sound, due to spasm of the larynx, will often be heard, but this will as a rule disappear as more chloroform is given.

While the patient is passing through the early stages of the inhalation the *pulse* is subject to many changes, but when the period of surgical anaesthesia arrives, it should settle down into a full regular rhythm of about the normal rate, and may even be slower than normal, especially in old people. If this regular and satisfactory rhythm is not established the cause must be sought, and remedied. As the operation proceeds the pulse tends to become gradually smaller and faster, and any obstruction to respiration will hasten this change.

The *face* is not flushed as with ether, but somewhat paler than normal, and this becomes more marked as the operation proceeds, and the pulse becomes feebler. If the face suddenly becomes pale during an operation it may be due to a condition of too light anaesthesia, and indicate a tendency to vomit. Or, on the other hand, it may be caused by an overdose, or by shock.

With chloroform the pupil is generally smaller than with ether, the average diameter being 2·5 mm. It is subject to the variations as described in Chapter I.

The *muscular system* is completely relaxed more quickly with chloroform than with ether, and for this reason it is to be preferred in certain operations, as to obtain a sufficient relaxation the ether must occasionally be pushed to an extreme limit. However, if a patient has been

anaesthetised with ether, and more complete muscular relaxation is required, this may often be accomplished by the use of very little chloroform.

Signs of Return to an Insufficiently Deep Anaesthesia

The respirations, which will probably have been gradually becoming very quiet, will almost or entirely cease for a time, the face become pale, and the pulse will be found small and fast ; the pupils, which had previously been quite small, will suddenly be found widely dilated, and there will be a brisk corneal reflex. Swallowing movements may occur, and the abdominal muscles, which had been relaxed, may now become contracted, and attempts at vomiting will be made.

Treatment.—If vomiting does not actually take place, the lips must be rubbed to stimulate the respiration, and more chloroform given. If the patient vomits, the mouth must be carefully cleaned before the administration is continued.

Signs of an Overdose of Chloroform

An overdose of the drug may be administered during the early stages, when it will be followed by the appalling signs of syncope, described on p. 51, which are so startling to the onlooker, and so fatal to the patient. The overdose may also be gradually given during the performance of an operation, when the onset of the symptoms may in consequence also be more gradual, and the prognosis more favourable.

The respirations become quieter and quieter, and finally cease. The pulse becomes smaller and smaller and imperceptible at the wrists, and the rate so increased that the beats can hardly be counted, and finally the circulation entirely fails. The face becomes livid, and cold to the touch. The muscles are relaxed, the corneal reflex will

be entirely absent, and the pupils widely dilated. The eyelids become separated, and the globes fixed.

The *treatment* of this condition is described on p. 52, and may here be briefly stated to consist of withdrawal of the chloroform, opening the mouth with a gag, and pulling the tongue forward with a forceps or a finger, lowering the head, artificial respiration, and the hypodermic injection of strychnine, with an enema of brandy in hot water. The patient should be kept thoroughly warm during all attempts to restore the circulation.

After-Effects of Chloroform

The risk of bronchitis and other respiratory troubles is less after chloroform than after ether, though such complications may arise. Existing bronchitis will generally be increased by the inhalation of any anaesthetic.

Vomiting after chloroform is slightly less common than after ether ; but when it does occur, it comes on at a somewhat later stage of the return to consciousness, when the patient is more capable of appreciating its unpleasantness, it is much more severe, and will last for a longer period. The treatment is described on p. 28. After the inhalation of chloroform the circulation remains depressed, and the patient should not be allowed to sit up for some hours after the return to consciousness. If this precaution is neglected *syncope* may occur, and has proved fatal.

" Delayed Chloroform Poisoning "

During the last few years cases have been recorded in which a patient, generally a child, has taken an anaesthetic perfectly well, and has recovered from its immediate effects. But after an interval of from 12 to 36 hours frequent vomiting has occurred, the vomit being at first watery and bile-stained, but gradually becoming more " coffee-ground " in character. The patient becomes excited and sometimes

maniacal. The temperature is seldom high, though occasionally it may rise to 106 degrees. The urine is scanty and contains albumen and casts, and acetone may sometimes be found in it, and may even be smelt in the breath. These symptoms may last for three or four days and then gradually lessen, but death may occur in twelve hours.

On *post-mortem* examination the most characteristic condition is the appearance of the liver, which is of a light fawn or canary colour. It is markedly fatty both to the naked eye and on microscopical examination, and similar changes may, to a less extent, be found in the kidney and heart.

This condition has followed the inhalation of chloroform much more frequently than any other anaesthetic, though cases have been recorded both after ether and ethyl chloride.

The exact share of the anaesthetic in the production of this condition has yet to be determined. It is obvious that chloroform is not the sole cause, or it would be much more frequent.

Guthrie, whose paper on the subject in the *Transactions of the Society of Anaesthetists* (Vol. 8) should be consulted for further details, thinks that a condition of fatty liver pre-exists, and that chloroform plays the part of " the last straw." Several series of cases have occurred in the same institution, and in some the possibility of sepsis cannot be excluded.

Guthrie considers that when a fatty liver is suspected, the patient should be kept on a diet restricted in fat for some days before the operation, and that bicarbonate or citrate of soda should be administered. When the above-mentioned symptoms are observed, the treatment should consist of mild purgation, with saline transfusion and the administration of bicarbonate of soda.

CHAPTER VII

MIXTURES CONTAINING CHLOROFORM AND ETHER

Chloroform and ether mixed in different proportions, in some cases with the addition of other drugs, have been employed in the hope that the unsatisfactory effects of the one will be neutralised by those of the other, and that the mixture will present the advantages of both. To some extent this hope has been realised. The mixture most in use is A.C.E.

A.C.E. Mixture

This was suggested by Harley, and was recommended by the Anaesthetics Committee of the Royal Medical and Chirurgical Society in 1864 as the most satisfactory of the mixtures examined by them. It consists, as its name implies, of a mixture of one volume of alcohol, two volumes of chloroform, and three volumes of ether. The ether and chloroform used in the mixture may be either "pure" or "methylated." The specific gravity of the mixture is about 1.

The use of the alcohol in the mixture has given rise to much discussion. It acts as a diluent of the chloroform, and is said to lead to a more intimate connection between the chloroform and ether, and to make the mixture more stable than one of chloroform and ether alone. At any rate, it is useful in disguising the smell of the ether, as that of the mixture is decidedly pleasant.

Schäfer and Scharlieb, from the results of experiments,

believe that the alcohol in the mixture is of much more importance than the ether. They consider that the ether is only a diluent of the chloroform, while the alcohol in the mixture is actually beneficial.

It is still undetermined whether any chemical change takes place during the preparation of this anaesthetic, or whether it is simply a mechanical mixture. Without doubt some amount of heat is generated during the process.

The objections to the use of a mixture are mainly theoretical. Some administrators consider that it is unsatisfactory to work with two drugs, without knowing the exact proportion of each one that is being administered; for the ether evaporates more quickly than the chloroform, while the alcohol remains till the last. This is undoubtedly to a great extent true, though the alcohol prevents the ether from evaporating as fast as it would if it were only mixed with chloroform. But practically the objection does not carry weight, for the anaesthetic has been given in many thousands of cases with excellent results.

The character of anaesthesia it produces lies midway between those procured by means of its two principal constituents, chloroform and ether, when used separately. By its use a quiet sleep is obtained resembling that of chloroform, while circulatory depression is less marked; in fact, the pulse generally improves soon after the substitution of this mixture for chloroform.

It may be given alone throughout the operation, or simply as a pleasant start for the administration of ether; and it is also most useful when a change is required on account of the amount of secretion produced by the latter drug.

Apparatus

The apparatus required for the administration of the A.C.E. mixture consists of a Skinner's mask and one known as Rendle's (Fig. 36).

Skinner's mask (Fig. 29) is used when the mixture is given to young children and delicate adults. The evaporation from this form of mask is so rapid, that it is unsatisfactory for an adult patient, and a semi-closed inhaler was suggested. It is dangerous to administer the mixture without a free admixture of air, and fatal results have followed its unintentional inhalation from a Clover's inhaler.

Rendle's inhaler was formerly made in leather; but as

FIG. 36.—RENDLE'S INHALER

this soon becomes contaminated, and cannot be easily cleaned, Silk substituted a celluloid form which can be easily cleaned, and is the best for general use. It consists (Fig. 36) of a more or less cylindrical inhaler made of celluloid, with holes at the closed end for the free admission of air, the other end being open, and approximately of the shape of the face, with a notch to accommodate the bridge of the nose. Air can easily enter through the holes, and the inhaler is not "closed" in its action, that is, re-breathing does not take place to any great extent, as it does when an india-rubber bag is used. The part applied to the face does not fit accurately, and there is no air-cushion round

the edge of the mask. The interior is lined with a flannel bag which contains one or two sponges, on to which the mixture is poured. If the bag becomes saturated during the course of a long operation, it should be changed for a fresh one.

These masks are made in three or four different sizes. A drop-bottle should be used, but, to prevent confusion, it should be of a different colour from the one used for chloroform. After an administration the sponge should be wrung out in hot water, the flannel bag should be washed, and the inhaler cleaned in a weak solution of carbolic acid in cold water.

The Administration

The A.C.E. mixture is given on a Skinner's mask in precisely the same way as chloroform, but as the mixture is much weaker than chloroform, more must be dropped on to the mask, and the time required to produce anaesthesia will be longer. Care must be taken that too much is not poured on the mask, as when the flannel is saturated, the liquid will drop on to the face, and blister it. In administering the A.C.E. mixture it must be remembered that the ether evaporates more rapidly than the chloroform. To obtain the greatest advantage of the ether it is best to give frequent small doses of the mixture rather than occasional large ones, for in the former instance the patient will frequently receive the beneficial effects of a small dose of ether, whereas in the latter case he will soon exhaust the ether in the mixture, and for the rest of the time will simply be breathing diluted chloroform.

This method of administering frequent small doses can be easily practised when the mixture is given from a Skinner's mask, as the inhaler in this case does not require to be moved when a fresh dose is applied ; but when the Rendle's mask is in use, it must be removed from the patient's face, and

inverted, before any fresh dose of the mixture can be poured on to the sponge. While this is being done the patient only breathes air, and so for the first part of the administration, that is till the patient is anaesthetised, larger doses must be given at longer intervals, and when a satisfactory state of anaesthesia has been obtained, then frequent small doses can be employed. When the administration is begun with a Rendle's mask, a drachm of the mixture is poured on to the sponge, and the mask is held three or four inches from the patient's face. As he becomes accustomed to the smell of the drug the mask is gradually brought nearer till eventually it rests against the face. The mixture is a pleasant anaesthetic to take, and coughing will seldom be met with if it is given with due care. After three or four minutes another dose of from half to one drachm should be poured on to the sponge. It is important that the liquid should be really poured on to the sponge, and not on to the flannel bag, as in the latter case the flannel will soon become saturated, and the liquid will trickle down on to the face and will burn it. When the mask is applied to the face care must be taken that the upper part of it is not held too close to the eyes, as in this way it may produce conjunctivitis. When the head has been kept well on one side during the inhalation, the conjunctivitis will be more severe in the eye that has been lowermost. The position of the patient, and the general management of the case, should be the same as during the administration of chloroform. When no nitrous oxide is available, or is considered unsuitable, ether may in some cases with advantage be preceded by A.C.E. To do this, some of the mixture is first given on Skinner's or in Rendle's mask, till the breathing becomes regular, when ether is substituted. If necessary it may be given first on a Skinner's mask, and then in a Rendle's, before the ether is given.

In the case of very feeble patients, or those suffering from

heart disease, when the administration of any anaesthetic is a matter of great anxiety, this mixture will generally be found the most suitable. It should be given very gradually on a Rendle's mask, preceded if necessary by a Skinner's, till the patient is anaesthetised. Then if there is any sign of failing circulation, pure ether may be poured on the sponge, or doses of the mixture may be given alternately with doses of ether, and this method will generally enable any patient to be kept unconscious. The addition of pure ether will also be useful when any patient who is inhaling the mixture shows signs of shock or haemorrhage.

If a change is desired from ether, on account of the excessive amount of mucus secreted, A.C.E. should be resorted to, for under ether the respirations are generally vigorous, and there is less risk of an overdose being given when the mixture is employed, than there is when pure chloroform is substituted for the ether.

The **drawback** to the use of the mixture is that it is slow in its action, and many patients, especially if they are alcoholic, take ten to fifteen minutes before they are well under its influence. But this time may be shortened by spraying 3 or 4 c.c. of ethyl chloride on the sponge, though great care must be exercised.

The **advantages** of the mixture are that it combines the good effects of chloroform and ether, without the bad results being so marked.

It is very useful for little children, as they breathe more deeply with a mixture, and the condition of "false anaesthesia" is not so easily induced as it is with chloroform.

Under A.C.E. the *breathing* is quiet and regular, not so vigorous and noisy as that under ether, but more easily heard than when chloroform is employed.

The *pulse* too is fuller than under chloroform, though it is

not so stimulated as by ether. There is less risk or trouble arising from causes connected with the circulatory system than there is with chloroform, and if any does occur, the onset will be less sudden and treatment of more avail, so that it is less easy to administer an overdose with this mixture than it is when pure chloroform is employed.

When the patient is well under the influence of A.C.E. the *pupils* will be somewhat larger than the pupils of chloroform anaesthesia, and smaller than the average ether pupil.

The signs of the administration of too little, and too much, of the mixture are practically the same as in the case of chloroform (see p. 164) ; and if a death occur with A.C.E., it will resemble one from chloroform.

The recovery after the use of the mixture is usually good. If vomiting occurs, it resembles that after chloroform in the onset being later than the vomiting which follows ether.

There will as a rule be rather more *mucus* secreted with the mixture than with chloroform, especially when it is given to young children, though there will be much less than with ether.

Laryngeal spasm may occur more frequently in the case of children than it does when chloroform is employed.

Mixtures of Chloroform and Ether in Other Proportions

When a mixture of chloroform and ether is made at the time of the administration its proportions may be chosen to suit the requirements of the patient. Those most commonly employed are the CE_2 (*i.e.* one part of chloroform to two of ether) and C_2E_3 (two parts of chloroform to three of ether).

These mixtures should be given precisely as the A.C.E. mixture described above. They should always be freshly prepared; and many administrators think that there is less vomiting on recovery when alcohol has been omitted from the mixture.

Schäfer and Scharlieb (*Trans. Roy. Soc. Edin.*, Vol. 41) consider that a mixture of one volume of alcohol with nine volumes of chloroform is preferable to any mixture of chloroform and ether.

CHAPTER VIII

THE CHOICE OF THE ANAESTHETIC, ETC.

Relative Safety of the Anaesthetic Agents

BEFORE considering the choice of an anaesthetic for any special patient, or for the performance of any particular operation, it is well that the student should have some idea of the relative safety of the drugs at his disposal.

By taking as the measure of their safety the number of deaths reported from these agents in proportion to the number of cases in which they have been administered, we find that nitrous oxide, either alone or mixed with oxygen, is the safest. Next comes ether, then mixtures of ether and chloroform, and last of all chloroform.

No reliable statistics of ethyl chloride are available, but its relative safety is probably between that of ether and chloroform.

The number of deaths which have occurred under **nitrous oxide** are so few, that they have never been reckoned against the enormous number of times that the gas has been given with safety, and so no figures indicating the proportion of deaths to the successes can be given; but there is no doubt that the anaesthetic is the safest that we possess. If one may judge by the published records of the cases which have ended fatally, it seems that this undesirable result has nearly always been due to asphyxia; but one or two cases at least have occurred in which the patient seems to have died of syncope.

No case of death from gas and oxygen has yet been published. This is due to the fact that it is not easy with this method to cut down the supply of oxygen to the patient to such an extent as to produce death from asphyxia, and also to the fact that the apparatus is somewhat complicated, and, in consequence, few but specialists use it.

With **ether** there are more definite figures to go on. Various tables have been drawn up, but on taking the average of these the number of deaths may be given as about 1 in 16,000.

But under **chloroform** many fatal cases have been reported, the death-rate being about 1 in 2,500.

Many of the fatal cases with both these anaesthetics are never reported, but these figures indicate sufficiently well that chloroform is much more dangerous than ether. The greater safety of ether was emphasised by Paul Bert, who described the administration of an anaesthetic as a journey along a road beset with difficulties on either side; but while that of ether is fairly broad, the path of chloroform is so narrow, that a step to one side may prove fatal.

There are no records of a sufficiently large number of cases to give any proportion for the **mixtures of chloroform and ether**; but the death-rate is probably between those of ether and chloroform given separately.

Too much importance must not be attached to these figures, for in some tables only those deaths directly attributable to the effect of the anaesthetic are given, while in others all cases are included of patients dying during anaesthesia, from surgical accidents, and other causes.

It is said that patients die from chloroform on the operating table before the eyes of the anaesthetist, while those who die from ether leave the theatre apparently well, and eventually die in their beds from bronchitis or pneumonia. This is to some extent true, for it is an undoubted fact that a death from chloroform generally occurs during the early

stages of the administration, while a death on the operating table from the effects of ether is very rare indeed. On the other hand, bronchitis and pneumonia, though not common, are less rare after ether than chloroform, and are the most frequent cause of death after this anaesthetic, though such complications have other factors in their production, such as exposure, etc.

The Choice of the Anaesthetic

Leaving the question of the relative safety of the agents with which we have to deal, the choice of the anaesthetic for individual cases must now be considered.

The two standpoints from which this must be regarded are (1) the patient and (2) the operation.

The Patient

In selecting an anaesthetic for a patient, his age, and general condition and state of health must be carefully considered.

Age

It has been laid down as a general rule that ether should be given only between the ages of six and sixty, and that beyond these limits chloroform should be the anaesthetic chosen. There is a great deal of truth expressed in this statement, but it must not be too rigidly applied. For instance, a man of fifty or less may be so aged beyond his years that he will be a worse subject for ether than a hale old man of seventy; in fact, the life a patient has led, together with his constitutional strength, are of more importance than his actual age.

Ether may be given to infants a few days old, or to patients at the other extreme of life, but in these cases it is liable to cause irritation of the respiratory tract; and chloroform, either pure, or in a mixture with ether, will be a better

anaesthetic. For infants pure chloroform is probably better even than mixtures, but children from three to six do best with a mixture of chloroform and ether. From six upwards ether may be tried, but it is more satisfactory after the age of ten. If it is being given soon after six, it is best to precede it with a little A.C.E., or even a few drops of chloroform, and reserve the use of nitrous oxide for the beginning of the administration to patients over ten.

When the patient has reached the age at which it is no longer desirable to give ether, chloroform must be the main anaesthetic, though a mixture with ether is in many cases better than pure chloroform.

To sum up only with regard to the age of the patient.—Up to the age of three years chloroform is the best anaesthetic; from 3 to 6, a mixture of chloroform and ether; from 6 to 10, ether preceded by A.C.E.; from 10 up to about 60, ether preceded by nitrous oxide. After 60, if it is decided to give ether, it should be preceded by A.C.E. rather than by nitrous oxide, as the arteries will probably be degenerated; but, as a rule, a mixture of chloroform and ether, such as the A.C.E. mixture, will be the best anaesthetic throughout.

General Condition of the Patient, and State of Health

Stout patients with short thick necks do not as a rule take ether well, because of the limitation of air by the inhaler, and the swelling of the tongue and upper air passages from congestion. It is better in these cases to begin with A.C.E., or chloroform, and when the patient is unconscious to try the effect of ether. They often become very cyanosed if gas is administered before ether.

A prop between the teeth is often a great help in these cases.

Strong *muscular* men will generally give the anaesthetist more trouble than women, and it should be remembered that a certain proportion of the deaths from primary cardiac

syncope have occurred when chloroform has been given to a labourer, fresh from his work, for the performance of some trivial operation. For these patients gas and ether should undoubtedly always be chosen, unless contra-indicated by the nature of the operation.

Alcoholic patients can take ether or chloroform, but often require a very large quantity to produce anaesthesia. The same remark also applies to persons who have been in the habit of taking large doses of morphia or other drugs. In alcoholic patients struggling and shouting will often be marked.

Anaemic patients can take any anaesthetic, but very soon come under its influence ; they should be allowed as much air as possible, and gas should never be pushed.

Heart disease.—In administering an anaesthetic to a patient suffering from heart disease, the most important point to determine is whether compensation is satisfactory. A dusky face, feeble pulse, difficult breathing, moist sounds at the bases of the lungs, enlarged liver, albuminuria, etc., are signs that the heart is not doing its work well ; and if an anaesthetic is required, great care must be exercised in its selection and administration. A systolic murmur heard at the apex is not of itself a contra-indication to the use of ether, though in any such case a careful watch should be kept upon the colour of the patient, so that the supply of air is not unduly curtailed. But in a case of imperfect compensation a closed inhaler should never be used. For these patients the best anaesthetic is A.C.E., or some other mixture of chloroform and ether. It may be given at first from a Skinner's mask, which may afterwards be changed for a Rendle's inhaler. The supply of air with the anaesthetic should be very free, and the patient should be carefully watched for signs of heart failure. Some patients with grave heart affections take this mixture very well. If the pulse fails some ether should be poured on

the sponge of the inhaler, and if the result is satisfactory the quantity may be increased until the patient is practically inhaling only ether. Ether is sometimes given from the first from an open inhaler, but this is not advisable on account of the suffocating feeling which it will produce in the patient.

Thoracic aneurysm.—For patients suffering from this disease A.C.E. is the most pleasant anaesthetic, and with its use there is generally the least amount of struggling, which of course must if possible be avoided. Ether would be unsuitable on account of its stimulating effect on the circulation.

Atheroma.—Patients suffering from marked atheroma should have chloroform or A.C.E. Those with a less amount may have ether, but it is advisable to precede it with a little chloroform, or better A.C.E., on a Skinner's mask, rather than to begin the administration with nitrous oxide. The possibility of the occurrence of cerebral haemorrhage in these patients must be remembered.

Ether should not be given to patients suffering from *acute congestion or inflammation of the respiratory tract*, such as laryngitis, acute bronchitis, or phthisis, but pure chloroform should be chosen. When the condition is *chronic*, such as old bronchitis with emphysema, A.C.E. will generally prove satisfactory.

When much *dyspnoea* exists from the narrowing of air passages from within, as in diphtheria, or from the pressure of tumours from without, as in enlarged thyroid gland, etc., chloroform should be chosen, and the anaesthesia should be as light as is possible for the satisfactory performance of the operation.

In all these cases of respiratory trouble, and in cases of empyema, especially if the operation be a short one, nitrous oxide and oxygen may be suitable. It will not increase the congestion or inflammation that is present, and unless

the patient is alarmed by the apparatus, its inhalation should produce no distressing symptoms. Considerable previous practice with this anaesthetic is absolutely essential before it should be given to such cases, and even then it may be found best to change to chloroform or A.C.E., but especial care must then be taken that an overdose is not administered.

"*Status Lymphaticus.*"—This condition has been blamed of late years as an important cause of death under chloroform.

Patients suffering from "status lymphaticus" have a large thymus gland, with enlargement of lymphatic structures throughout the body, such as the tonsils, lymphatic glands, the spleen, the papillae of the tongue, and Peyer's patches in the intestines.

There is no doubt that sudden death has occurred in children apparently healthy, without any obvious cause, and generally unconnected with the inhalation of an anaesthetic, and on *post-mortem* examination the structures mentioned above have been found enlarged.

Two theories have been advanced to account for death, the first, that it is the result of pressure on the air-passages, the second, that it is due to toxaemia.

The diagnosis of "status lymphaticus" has generally been made after death, but it is stated that it should be recognised during life by the enlarged tonsils, lymphatic glands, the spleen, and the enlarged papillae at the base of the tongue. Death has occurred far more frequently under chloroform than under ether, so that if this condition is diagnosed, ether should certainly be chosen as the anaesthetic.

In cases of marked *cellulitis of the neck* ether is unsatisfactory. Not only would it increase the congestion that already exists, but, as in these cases there is generally also some oedema of the glottis, and this would be

aggravated by the irritating influence of the anaesthetic, the respiration of the patient would be further embarrassed. For these cases, if not severe, the A.C.E. mixture will be satisfactory, but for bad cases pure chloroform will be required.

Albuminuria.—Ether in any quantity should not be given to patients suffering from albuminuria; for it is excreted in part by the kidneys, and if much has been inhaled, the nephritis may be made worse, and the amount of albumen in the urine increased, and in severe cases there will be a risk of total suppression of urine. Chloroform is the best anaesthetic for severe cases, but in mild cases the quantity of ether in the A.C.E. mixture will probably do no harm, though ether alone should be avoided.

Shock and collapse.—Patients in a state of severe shock and collapse from accidents, loss of blood, or prolonged exposure, etc., require very little anaesthetic for any operation. Ether is the most suitable, though it should be given sparingly, and with plenty of air. It should not be given, however, when there is any coexistent respiratory trouble, or any haemorrhage that might be increased by its stimulating effect, and for these cases chloroform or A.C.E. may be employed.

The Operation

The operation to be performed affects the choice of the anaesthetic in two ways: (1) by its probable length, (2) by its necessities.

Length of the Operation

For operations not lasting more than ten minutes the use of gas with air or oxygen should be considered. It is pleasant to take, is safe, and as a rule recovery is rapid, and without complications, such as vomiting. For these short cases ethyl chloride is also suitable.

For longer cases it is generally better to resort to ether, chloroform, or a mixture, except under exceptional circumstances, as when it is important that the patient should be able to return home as quickly as possible. Under such special circumstances gas and air, or gas and oxygen, may be given for half an hour or more ; but the longer the anaesthesia, the more chance there is of recovery being complicated by vomiting, headache, and giddiness, which may render the patient in some cases as prostrate, and as unable to move, as he would be after one of the other anaesthetics.

The Nature of the Operation

If **nitrous oxide** is considered satisfactory as regards the length of time required by the surgeon, there are very few operations for which it may not be employed. It is specially suitable for those in which great relaxation of the muscles is not required, and where a slight muscular movement would not spoil the operation ; and it is also satisfactory for operations which do not require great delicacy in their performance. It may be given with the usual apparatus for all operations except some about the face, or in the mouth, and for these the nasal method of administration may be satisfactory. For quite short operations the gas may be given as for a dental operation, and the face-piece then removed ; but the anaesthesia thus obtained will not be long enough for the performance of many surgical operations. If for any reason gas is not considered advisable, the choice now lies between ether and chloroform, or one of their mixtures.

On account of its greater safety ether should be tried in all cases, except the following :—

(1) When it would be unsatisfactory on account of the *congestion* it produces, as in operations on the brain, removal of the thyroid gland, operations on the eye, the larynx, and trachea.

(2) When an excessive *secretion of mucus and saliva* would increase the difficulties of the surgeon, as in some operations in the mouth and larynx.

(3) When *inconvenience* would be caused by the size of the apparatus, as in operations on the eyes, nose, lips, and tongue. Many of these cases, however, may be anaesthetised with ether, and chloroform substituted later.

(4) When a *cautery* has to be used near the mouth, it is better to administer chloroform from the beginning.

(5) In all cases where only a *light anaesthesia* is required chloroform is preferable to ether; such cases are painful labour, eclampsia, and tetanus.

(6) In some cases the surgeon will specially wish for chloroform—often for *abdominal sections, etc.*—on account of the quieter breathing, etc.

In all other instances, unless there is some good reason to the contrary in the general condition of the patient, ether should be tried as the anaesthetic; and if it prove unsatisfactory, on account of the secretion of mucus, or the deep and rapid breathing it may produce, a change should be made to **chloroform** or **A.C.E. mixture.**

Notes on Certain Operations

Operations on the Brain and Cranial nerves

Chloroform is by common consent the best anaesthetic for these operations, as it does not cause congestion of the part, and oxygen is often useful in combination with it. A hypodermic injection of morphia has been recommended just before the administration, in order to render the parts more bloodless, but this has now been abandoned by most operators.

The patient should be anaesthetised in the dorsal position, and when he is quite unconscious, gradually lifted into the

position that the surgeon requires. He will often have acquired a habit of taking morphia and other drugs on account of pain, and will then require more of the anaesthetic than usual. Many of these patients have a marked tendency to vomit. It is very important that a good airway should be kept, as if there is any obstruction to free breathing, the veins will become dilated, and the area of operation as congested as if ether had been administered.

When the operation is in progress the anaesthesia is best maintained by means of a Junker's inhaler with a glass or celluloid face-piece (Fig. 32). In this way the patient can be kept in a suitable degree of unconsciousness, without the administrator having to bring his hand near the wound to drop chloroform on a mask. The face-piece being of glass can be made aseptic, and a fresh piece of lint, with an outer layer of antiseptic gauze, can be used to cover it. The colour of the lips, and their movement in respiration, can be seen through the glass. If the patient is breathing vigorously, and any saliva collects on the lips which might be blown about, this mask is of service in preventing anything from reaching the wound or the surgeon's instruments, as it can be kept closely applied to the face on the side nearest the seat of operation, and elevated on the other for the admission of air.

Anaesthesia may be induced with this apparatus, and if more chloroform is required than can be pumped through the tube, some may be dropped on the lint covering the face-piece. As one of the administrator's hands will be required to compress the bellows, the other must hold the face-piece and keep the jaw in good position, and this is best done by holding the face-piece by its lower end, and by keeping some of the fingers of the same hand under the patient's chin. A light anaesthesia should be maintained, but straining or coughing must be prevented, as these would often render the operation impossible.

Removal of the Thyroid Gland

Chloroform is the best anaesthetic for these cases, as it produces the least amount of congestion. It may be administered from a Skinner's mask, but it is better to use a Junker's inhaler with the glass or celluloid face-piece described above. After once being anaesthetised, these patients often require very little chloroform to maintain the proper degree of anaesthesia.

The administration of an anaesthetic to these patients is always attended with some anxiety, as they seem particularly liable to syncope under chloroform. The air-way is probably narrowed by the pressure of the enlarged gland, and in the course of the operation the manipulations of the surgeon may further diminish the calibre of the trachea.

The patient should never be anaesthetised more deeply than is necessary. The skin incision is said to be the only painful part of the operation, so that when this has been made it is advisable to try a lighter anaesthesia. Muscular movements, swallowing, and attempts to vomit, are signs of insufficient anaesthesia ; and if the corneal reflex can be allowed to return without these troublesome complications, it should not be abolished again.

On account of the special danger in these cases, this operation is sometimes performed under local anaesthesia obtained by cocaine. But most surgeons prefer the patient to be unconscious, as swallowing and other movements are embarrassing.

Several cases have been recorded in which respiration and circulation have failed during one of these operations, generally when the main vessels and nerves were being manipulated, or when the tumour was lifted from its bed ; and death has sometimes resulted. In many instances this is due to a closure of the trachea through traction on the gland, but in others it seems to be due to some nervous

stimulation exerted through the manipulation of the vagus and its branches, or through the sympathetic nerves. If respiration ceases it is useless to attempt to restore it artificially until there is a sufficiently free air-way. Owing to the size of the tumour, tracheotomy below the obstruction may be impossible, and intubation may be of great service.

The pressure of the enlarged gland often causes the trachea to assume a sinuous course, and as tracheotomy may become necessary during the removal of the tumour, it has been suggested that the exact position of the trachea should be made out by auscultation before the operation is begun.

Tracheotomy

When this operation is performed for the relief of urgent dyspnoea it is sometimes only necessary to freeze the skin with ethyl chloride, and even this may be omitted when the operation is one of emergency. But when dyspnoea is not marked, and also when the tracheotomy is preliminary to the removal of the tongue, or some such operation, chloroform should be given, but the anaesthesia should be as light as possible. In children especially the difficulty of breathing is increased by fright, but a little of the anaesthetic will soon relieve this, the breathing will become easier, and the neck will become less congested as the struggling passes off. In performing the operation for the relief of urgent dyspnoea it is unwise to push the anaesthetic beyond this stage of quiet.

The patient should be in a position as nearly dorsal as possible, though the difficulty of breathing may render the absolutely supine position too trying for the patient. The head should be extended, and the chin exactly in the middle line ; and it must be rigidly kept in this position by the anaesthetist, for the difficulties of the operation are greatly increased by an altered relation of the parts. In this

position the tongue tends to fall back against the posterior wall of the pharynx, but the air-way must be kept as clear as possible by pressing with a finger behind the angle of the jaw on one side, if not on both. If this is insufficient to keep the tongue forward, tongue forceps must be used.

Removal of Post-Nasal Adenoid Growths

There is perhaps no operation in surgery which has so many methods of performance. The surgeon may wish the patient to be sitting bolt upright in a chair, sitting up with the head bent well forward, or lying in the dorsal position with the head extended, or even hanging over the end of the operating table or couch.

Any position may be adopted when gas, ethyl chloride, or ether is chosen as the anaesthetic, but for the administration of chloroform, or mixtures containing it, the patient must be recumbent.

The length of the anaesthesia required varies with the amount of growth to be removed, and with the speed at which the operator works. For some operations the 40 seconds of anaesthesia which may be obtained as the result of one administration of gas and air, or gas and oxygen, will suffice. A slightly longer anaesthesia may be obtained with ethyl chloride, while for the cases requiring some minutes of anaesthesia gas and ether may be chosen on account of its greater safety, though most operators prefer chloroform, or the A.C.E. mixture, on account of the congestion and secretion of mucus and saliva which so often accompany the inhalation of ether. After the operation has begun, anaesthesia may be maintained, when necessary, by chloroform given with Junker's inhaler, but the patient runs less risk if anaesthetised in the first instance with ether.

In giving gas and ether for these cases it should be remembered that if the nose is obstructed by the growths, and the mouth is kept closed by the hand which holds the face-

piece, the patient will soon be practically asphyxiated, as will be shown by the bad colour of the face. To prevent this, it is well before beginning the administration to see if the nostrils are patent, and if they are occluded a small dental prop should be placed between the teeth on the right side, so that an air-way through the mouth shall be maintained throughout the administration. It is better

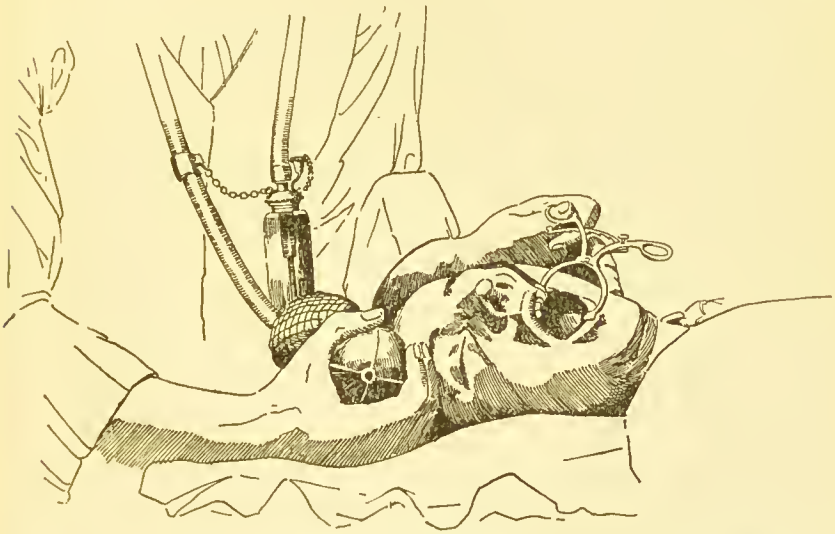

FIG. 37.—THE ADMINISTRATION OF CHLOROFORM WITH A JUNKER'S INHALER FOR THE REMOVAL OF POST-NASAL GROWTHS

placed on the right side, as it will then be out of the way of the gag, which is generally placed on the left.

The patient should be anaesthetised with the head turned to the right. When the corneal reflex is abolished the inhaler should be removed, and the gag inserted. Care should be taken that it rests on sound teeth, and as far back as possible. When Mason's gag is used the upper arm of the gag should lie across the left external auditory meatus, and should be kept stationary, while the lower arm should move till the mouth is opened as widely as

desired. As the gag is opened widely the lower jaw is gradually forced towards the sternum ; and to counteract the obstruction to respiration which would ensue as the result of this, the jaw must be pushed forward by means of a finger behind the angle. This can conveniently be done by one of the fingers of the left hand, while the gag is kept in its place by the others. If a detached tube is being used to convey the chloroform to the mouth from the Junker's inhaler, it should lie between the two arms of the gag, but is more convenient if the tube is fixed to the gag (Figs. 33 and 38).

If both tonsils are to be removed, it is as well to have two gags at hand, so that no time is lost in changing the one from side to side. But with the gag shown in Fig. 38, which has been modified from one suggested by Doyen, a change is rendered unnecessary, as the gag rests on the incisor teeth, and does not get in the way of the tonsillotome. Chloroform may be given through the tube attached to the upper arm of the gag, and this tube can be easily cleaned. As this gag fits closely to the patient's face, it may take the place of the dental prop, and be placed in position in the mouth before the administration is begun, and be opened to the desired extent when the patient is anaesthetised. As it rests on teeth which are not so strong as those further back in the mouth, care is required in adjusting it in position.

The surgeon will probably wish the head to be kept in the middle line, and this position must be maintained by means of the anaesthetist's hands placed one on each side of the head, the ball of the bellows of the Junker inhaler lying in the palm of the right hand.

When blood has to be sponged from the back of the mouth the head should be turned over to the right side, and replaced in the middle line as soon as the surgeon is ready to continue the operation. By turning the head to

the right when blood has accumulated in the mouth, less of it will be swallowed, and the patient will be less likely to vomit on coming round.

The depth of anaesthesia required by operators varies considerably. Some wish the soft palate to be quite relaxed, and no reflex movement to occur when a finger is passed into the pharynx. Others consider the anaesthesia

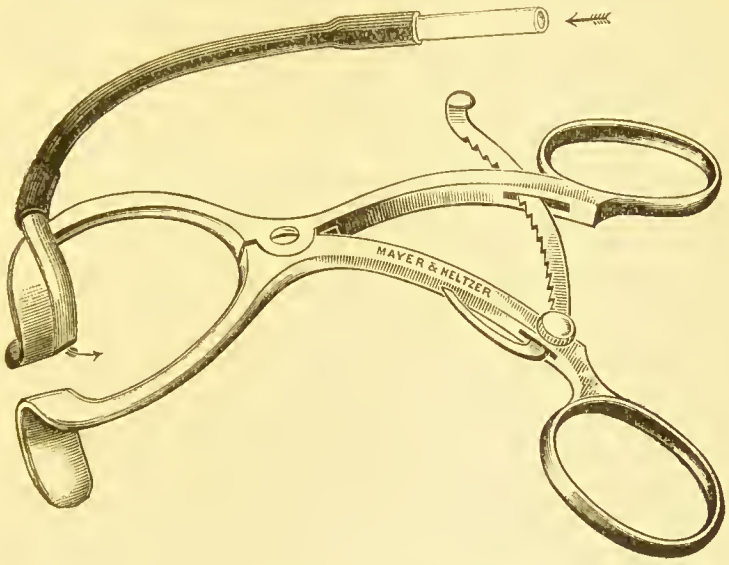

FIG. 38.—PROBYN-WILLIAMS' GAG FOR OPERATIONS IN THE MOUTH AND POST-NASAL SPACE, ETC.

too deep unless they can feel a distinct reflex on touching the soft palate.

The patient should always retain a slight coughing reflex, so that blood which may enter the larynx shall be at once expelled. At the same time, the soft palate should be relaxed so that the surgeon may have no difficulty in passing the forceps behind it; and no attempt at vomiting should be caused by the contact of the finger with the pharyngeal wall.

When the operation is not a long one, a sufficient depth

of anaesthesia may be kept up by means of the Junker's inhaler; but if the patient is robust, it may occasionally be found necessary to give a stronger vapour from a Skinner's mask. While this is being done, the gag should be relaxed, as the patient will breathe more freely if the mouth is not widely opened. When the mouth is almost full of blood, and the surgeon's finger is practically filling up the post-nasal space, it is useless to pump chloroform into the mouth. The anaesthetist must wait till the blood has been removed, the air-way is free, and the patient is breathing regularly.

When the operation is concluded the patient should be turned bodily over on to the right side, and the right leg bent at the knee to prevent his rolling from side to side. In this position any blood that may collect will probably run out of the mouth and not be swallowed.

The application of iced water to the face will lessen haemorrhage, and will help to hasten the recovery.

Operations for the Relief of Empyema

The choice of the anaesthetic for a patient suffering from empyema depends principally on his general condition. If the collection of pus is not large, and the respiration is easy, gas and oxygen may prove quite satisfactory, except in those cases where the mere presence of the large apparatus is a source of great discomfort to the patient. Failing this, the A.C.E. mixture, or even chloroform, may answer very well. The anaesthetic should be given very gradually and cautiously. It is best to start with a Skinner's mask, and if the A.C.E. mixture is being given, a Rendle's inhaler may be substituted after two or three minutes.

It is better to avoid ether, and, on the whole, the A.C.E. mixture will be found the best routine anaesthetic for

these operations. The anaesthesia should always be light, and the corneal reflex never lost. If no rib is to be resected no more anaesthetic will generally be required after the skin incision.

The *position* of the patient for this operation is most important. The administration should be begun in the position which the patient naturally assumes as the one of greatest ease. During the operation much depends on the wishes of the surgeon, but the anaesthetist must see that the position adopted is also satisfactory from the patient's point of view.

It is most important that the sound lung should be uppermost, and that respiration should not be impeded by assistants leaning on the chest. If the diseased side has been placed uppermost, and the empyema has a communication with the bronchus, the pus may run into the bronchus of the sound side, and the patient be asphyxiated.

One very good position is for the body of the patient up to the waist to rest on the operating table, while the head and shoulders rest on another table placed at the side, or are supported by an assistant. In this way the sound side can be kept uppermost, while the surgeon has plenty of room to get at the affected part. The arm rest shown in Fig. 39 may also prove useful.

When there is a large accumulation of pus in one pleura, especially the left, the heart is displaced from its normal position. The sudden evacuation of the cavity is often followed by fatal syncope, and in these cases the patient runs less risk when the surgeon removes the pus gradually by means of Turner's tube, or by aspiration, and postpones the administration of a general anaesthetic, which will be necessary for the resection of a rib, etc., for two or three days, when the heart's action will be less obstructed.

Operations through the Loin

For operations in this region, such as are mostly performed on the kidney, as nephrectomy, nephro-lithotomy, etc., the position of the patient is of importance to the anaesthetist as well as to the surgeon. For the convenience of the operator the patient is placed on the sound side,

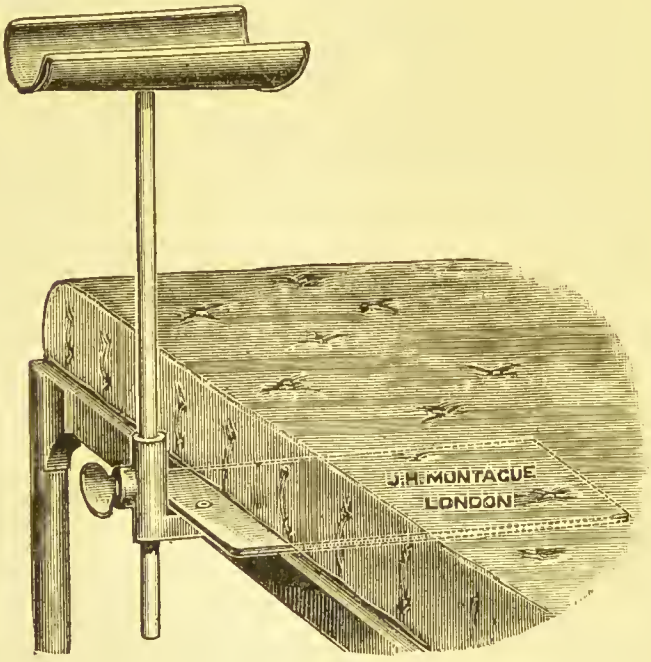

Fig. 39.—Carter Braine's Arm Rest

with a small pillow under the loin. In this position respiration is not very easily performed, especially when, by the desire of the surgeon, force is exerted in pressing the kidney near to the incision. The patient cannot use the lung of the dependent side to its full extent, and tends to bury his face in the pillow; and it becomes the duty of the anaesthetist to see that he is using the uppermost side of the

chest to the best possible advantage. To ensure this, the shoulder which is uppermost must be kept in position by an assistant, or by bending the arm to a right angle and fixing it in its position by bandaging, or by the use of a rest suggested by Carter Braine (Fig. 39). This consists of a broad iron plate, which is kept in position by being pushed under the mattress on which the patient is lying, and which forms the base of the apparatus, while to it is attached an adjustable sliding rod, at the upper end of which is the support on which the arm rests. When this rest is used the breathing is less hampered, and the patient remains still in the position desired by the surgeon. When ether is being administered to patients in this position the angular tube (Fig. 26) is useful.

Anaesthetics in Abdominal Surgery

On account of its greater safety, ether, preceded if possible by gas, should be chosen for short operations, unless it is contra-indicated by the state of the patient.

Though extreme muscular relaxation is not secured as quickly as with chloroform, still the necessary amount can nearly always be obtained in a short time.

For many delicate operations the depth and rapidity of the respirations under ether may be troublesome for the surgeon, and then a change must be made to the A.C.E. mixture, or chloroform. This change may also be necessary if the secretion of mucus and saliva is excessive ; and it should be remembered that even a moderate amount of mucus may prove a source of discomfort to a patient, who on his return to consciousness may find difficulty in removing it, on account of the position in which he is lying, and from the reluctance to cough which is caused by the pain produced in the abdominal wound by so doing. If this is not borne in mind, and much mucus is allowed to

accumulate, bronchitis, or even broncho-pneumonia, may follow.

Another reason against the prolonged and excessive use of ether in these cases is that during the operation the amount of shock which the patient is suffering is masked by the temporary stimulation of the ether, but when this is withdrawn, and the patient is back in bed, a very grave condition of shock supervenes. From fear of this, and with a wish to know the exact condition of the patient, so that if much depression is caused the operation may be curtailed, chloroform is still regarded as the best anaesthetic by many surgeons.

The best routine method is to start with gas and ether, and, if the operation seems likely to be prolonged, to change to A.C.E., or chloroform, after about twenty minutes, or half an hour, according to the way in which the patient is taking the ether. But there are many cases which do better with chloroform or one of its mixtures from the beginning, and these can only be recognised after a certain amount of practical experience.

Anaesthetics in Midwifery

For the purpose of relieving the pain caused by strong uterine contractions a very light anaesthesia is all that is necessary, and this may best be obtained by means of chloroform, or A.C.E. mixture. Chloroform is sometimes given with a Junker's apparatus, the bottle being suspended to the head of the bed, and the patient herself compressing the bellows. It is said that this method is perfectly safe, as when the patient becomes sleepy from the chloroform she naturally relaxes her hold on the bellows, and thus the supply of vapour is stopped. But this course cannot be recommended, any more than that of allowing a nurse to administer the anaesthetic.

For the low application of forceps a similar degree

of anaesthesia will generally be sufficient; but for a difficult high operation the anaesthesia must be more profound, and it may be necessary to abolish the corneal reflex. In these cases, and for the other operations of midwifery, such as turning, and the immediate suture of a badly lacerated perineum, the anaesthesia may be obtained by chloroform or A.C.E.; but ether is applicable, and safer.

CHAPTER IX

LOCAL ANAESTHESIA

In this country the use of local anaesthesia, or more correctly analgesia, is small compared with that on the Continent and in America; and most operations are performed under general anaesthesia.

Advantages of Local Anaesthesia

The principal advantage of this method is that no preparation of the patient is necessary: in fact, it is better that he should recently have taken food.

The patient does not lose his consciousness, which is to some people a great cause of dread, even when the general anaesthetic to be taken is as pleasant as nitrous oxide. In some operations it may be of assistance to the surgeon that the patient is able to make certain movements when directed to do so; but this can be so seldom, that it can hardly be counted of much value.

The **disadvantages** of local anaesthesia are as follows :—

In the first place, the knowledge that an operation is being performed on his person, however slight that operation may be, and although no actual pain may be felt, may cause such a general nervous disturbance, that the patient may be more collapsed than after a general anaesthetic. This is intensified by the sight of the instruments and the movements of the operator.

If the patient is not nervous, and bears the operation

calmly, some movement on his part, even a cough, may ruin a delicate operation. At all times the action of local anaesthesia is uncertain, and it is well to have a general anaesthetic at hand to fall back on in case of need.

If the operation is extensive, or lasts a long time, symptoms of poisoning by the drug employed may be observed, and a fatal result has followed the use of one grain of cocaine.

Local anaesthesia is quite inapplicable for some operations in which it has been tried, as, for instance, in those on the stomach and other hollow viscera, which it is impossible to anaesthetise by local measures.

After the performance of an operation under a local anaesthetic suppuration follows more frequently than when a general anaesthetic is given, and if cold has been employed as the means to produce the required analgesia, the pain is sometimes very great as the part becomes thawed, and occasionally the skin may slough.

When much liquid is used, especially in the infiltration method, the parts become so swollen and oedematous that they are with difficulty recognised, and a delicate dissection is impossible.

Cases Suitable for the Use of Local Anaesthesia

The cases which are most suitable for the employment of a local anaesthetic, and to which the use is generally confined in this country, are small operations on the fingers or toes, when the part can be so steadied that a slight movement will probably not do much harm ; removal of tumours from the mucous membranes or skin, as polypi in the nose ; the use of the cautery, as for granular pharyngitis ; the removal of foreign bodies from the eye, etc.; as a preliminary to the passage of a urethral or Eustachian catheter; for opening abscesses that are already pointing ; for a simple incision into some part, or before an exploratory

puncture ; or for the performance of some severe operation on a patient who is almost moribund, or whose general condition precludes the use of a general anaesthetic.

Methods of Producing Local Anaesthesia

There are three principal ways in which anaesthesia may be obtained locally : by cold, by the use of drugs, such as cocaine, and by means of Schleich's infiltration method.

The Use of Cold, or Freezing

The earliest way in which local anaesthesia was produced consisted in freezing the part by a mixture of **ice and salt.** If other means are not at hand, this may still be of service in some cases, and may be applied by making a mixture of two parts of ice pounded into small pieces with one part of salt. This should be placed in a rubber bag, and laid on the part till it is frozen, as may be judged by the whitened appearance of the skin, its hardness, and its insensitiveness to touch.

When the skin is thus rendered insensitive the operation may be performed, but it should not consist of more than a simple puncture or incision, as the frozen skin will prevent any delicate operation.

The great drawbacks to this method are that a much larger area of skin is rendered insensitive than is actually necessary for the performance of the operation, that when thawing sets in the pain may be very severe, and that the whole area of skin that has been frozen may slough.

A better way of freezing the skin is to use the cold produced by the evaporation of volatile liquids, such as ether, and in this way the area of the skin frozen can be more accurately limited to the actual seat of the operation. This may be done by the **ether spray,** which consists of a bottle containing ether, to which a small india-rubber ball-bellows is attached. When the ball is compressed the

ether is driven out in a fine stream. Care should be taken that the bottle is held sufficiently far from the part that the ether may fall in a fine spray, for in this way the freezing will be produced more rapidly. The ether used in this apparatus may be the ordinary methylated ether which is used for inhalation, or what is known as "anaesthetic ether," which should never be used for inhalation. Other volatile liquids are employed to produce cold for this purpose, as **ethyl chloride, "anaestile,"** etc. They are quite satisfactory, and are supplied in convenient bottles, so that when held in the hand the heat will be sufficient to drive a small spray on to the part to be frozen.

The Use of Drugs

The drug most commonly employed to produce local anaesthesia is **cocaine,** but as the alkaloid itself is practically insoluble in water, the hydrochlorate is generally used. This is freely soluble, but the solution should be fresh, as, if it is kept for any length of time, fungi will grow in it. To remedy this, boric acid, or 5 per cent. of salicylic acid, should be added to the solution, which will then keep better, though not perfectly well. Cocaine is used in solutions of different strengths, generally of about 5 to 15, or even 20 per cent., but of late years it has been found that solutions of much weaker proportions produce equally good results, and for many purposes the strength has been reduced to 1 or 2 per cent.

As stated above, one grain of cocaine used to produce local anaesthesia has resulted in the death of the patient, so when the operation is extensive or prolonged, this possibility must be remembered, and not more than a half, or at the most three-quarters, of a grain should be given. Even this might be too much for some patients, and watch must be kept for any indications of poisoning, such as will be enumerated later.

Methods of Application of Cocaine

1. *Instillation.* A few drops of a 4 per cent. solution are dropped into the eye; this is repeated in two or three minutes, and then in ten minutes the patient will be ready for operation.

This is the method now generally employed for the removal of foreign bodies from the cornea, operations for cataract, etc., and for others in which the surgeon does not require a general anaesthetic.

Instead of instillation a soluble tabloid is sometimes placed under the lid; or for the removal of a Meibomian cyst the lid may be turned back, and some of the alkaloid rubbed on it.

2. *Spraying.* This method is used for small operations on the nose, mouth, or throat, and a solution of 4 per cent., used in a small ball-bellows spray-producer, will generally be sufficient. The part is sprayed two or three times, and then five minutes should be allowed for the drug to take effect.

3. *Painting.* For mucous membranes a solution of 10 per cent. is painted on the seat of operation. This may be repeated, and after the usual interval of five minutes, the operation can be performed.

For anaesthetising the skin this strength will not be sufficient, and it should be increased to 20 per cent.

Instead of painting the part with such a strong solution, a small piece of cotton wool may be soaked in a weaker solution, about 5 per cent., and then kept on the seat of operation for five minutes. This method is frequently employed for operations in the nose, and the cocaine solution is often mixed with equal quantities of the ordinary preparation of adrenalin (1–1000) in order to render the mucous membrane as bloodless as possible.

4. *Hypodermically.* In this method from three to five

minims of a 5 or 10 per cent. solution are injected under the skin at the seat of operation. If the area is large, two, three, or more injections should be made in different directions, and if the operation is prolonged these must be repeated. Care must be taken that the fluid is not injected into a vein.

In operations on the fingers the effect of the cocaine will be increased if an india-rubber band be applied as a tourniquet round the base of the finger, and it is probable that in this way the effect of the cocaine is more completely confined to the affected part.

For the passage of a catheter the urethra may be rendered almost insensitive by a previous injection into it of a few minims of a 2 per cent. solution of cocaine.

For certain dental operations, as the fixing of rubber round the teeth, the patient may be spared much pain by the use of a 10 per cent. solution rubbed on the gums.

Injections of cocaine into the gums are given before the extraction of teeth, but the results are not uniformly satisfactory, and symptoms of poisoning have followed the use of the large doses which are sometimes necessary.

Eucaine

Eucaine hydrochloride, α and β, are two substances chemically different, but both possessing local anaesthetic properties. They are not so powerful as cocaine, and seldom cause symptoms of poisoning.

The solutions of these drugs in water may be sterilised by boiling without affecting their anaesthetic properties. β eucaine is generally used.

In *ophthalmic* work α eucaine is unsuitable on account of the irritation which it produces. This is not noticed with β eucaine, which is used in a 2 per cent. solution in water, while both possess a great advantage over cocaine in not causing dilatation of the pupil.

A 5 per cent. solution of β eucaine in water is used for nose and throat work, and the same solution is suitable for *hypodermic* injection, and is rarely followed by any of the constitutional symptoms which are a great drawback to cocaine. Up to 1½ drachms of the solution may thus be used, and the anaesthetic effect is soon produced.

Symptoms of an Overdose of Cocaine

Patients vary very much in their susceptibility to this drug, and what may be to one an insufficient dose to produce any anaesthetic effect, may to another be poisonous, and sufficient to cause alarming symptoms, and perhaps even death. Fatal cases have been recorded in which the dose seems to have been very small.

The principal symptom of an overdose is a feeling of giddiness, accompanied with a great difficulty in breathing. The patient becomes pale, with dilated pupils, and a cold sweat on the forehead. The pulse is generally slow and feeble, and palpitation is frequently noticed. The patient is often extremely restless, and may be delirious, or irregular convulsive movements may occur.

Treatment

If the patient seems very nervous, and has not taken food for some time, the preventive treatment consists in giving a little stimulant before the application of the cocaine; and whenever the nature of the operation will allow it, the recumbent position should be chosen.

When the first sign of an overdose appears he should be laid flat on his back, with feet raised and head dependent.

Ammonia, or nitrite of amyl, should be held to the nostrils, and, if the breathing is deficient, artificial respiration must be employed. Any clothing that may be obstructing respiration must be loosened. Hot bottles should be placed round him, and, if he is able to swallow, he should be

given brandy and water to drink. If swallowing is not possible, some brandy should be rubbed on the lips and tongue till he is able to take more. He should not be allowed to stand up till he is quite recovered, and hot tea or coffee will often be of use in restoring a feeling of comfort.

If antipyrine in the proportion of 8 grains to 1 of cocaine be added to the solution, the poisonous effects of the cocaine are said to be less marked.

Schleich's Infiltration Method

By this method a normal saline solution containing a small proportion of cocaine is injected first into the skin, and then into the deeper structures at the seat of operation.

For his first experiments Schleich used a saline solution without any drug which could produce local anaesthesia; but he found that far better results were obtained when cocaine, even in very minute quantities, was added to the solution.

He uses three solutions, varying in the amount of the cocaine which they contain—the first, or strongest, for operations where the greatest degree of anaesthesia is required; and the third, or weakest, for those where the anaesthesia required is only slight.

Their compositions in grammes are as follows:—

	1	2	3
Cocaine hydrochlor.	2·0	1·0	0·1
Morphia hydrochlor.	0·2	0·2	0·05
Sodii Chlorid.	2·0	2·0	2·0
Aq. destil. et steril.	1 litre	1 litre	1 litre

The second solution is the best for most cases, the first being only required when the part to be operated upon is naturally very tender, or has become so from inflammation. The third solution is employed when the operation covers a large area, or is very prolonged, so that many applications of the fluid are necessary. Of the first or

strong solution no more than 25 c.c. should be used, while 100 c.c. of the second, or 500 c.c. of the third, have been used for one operation.

β eucaine may be used for this method; Martindale supplies it in a powder, suggested by Barker, containing 3 grains of β eucaine and 12 grains of sodium chloride to be dissolved in $3\frac{1}{2}$ ounces of water.

Method of Procedure

After the skin has been sterilised some of the fluid is injected into it at the seat of operation. It must be emphasised that at first the injection is into the skin, and not

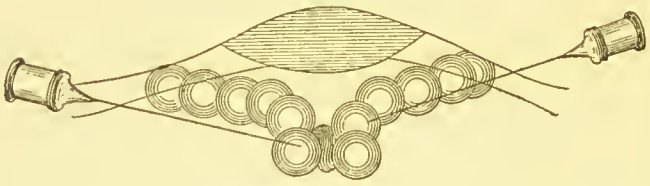

FIG. 40.—DIAGRAM TO ILLUSTRATE SCHLEICH'S INFILTRATION METHOD. A wheal is formed by each injection

under it, as in the ordinary hypodermic injection of cocaine. The syringe is specially constructed to overcome the resistance of the skin to the injection of fluid into it, and it can be easily sterilised. It holds about 10 c.c. of the solution.

The presence of the solution in the skin raises a small wheal, and into the edge of this the next injection must be made, the process being continued till a ring of wheals has been formed round the area of operation. The fluid is next injected under the skin, and, when necessary, into the deeper structures.

When this method is properly carried out the skin is rendered quite insensitive, but, as the first incision is made, much of the fluid escapes. As a rule, the anaesthetic

effect lasts for about twenty minutes, but it may be prolonged by further injections. The fluid should not be injected into parts which contain much loose connective tissue. As in the use of the other local anaesthetics, it is better for the patient to have had some food within a short interval of the operation, and a stimulant given just before the injection will help in preventing shock.

This method is not employed very extensively in this country. Considerable time is taken to render the part anaesthetic, and fresh additions of fluid must be made from time to time when the operation is prolonged. This so alters some structures as to perplex the surgeon who is not accustomed to the method; and after it there is a risk of suppuration occurring. In an extensive operation shock may be so severe, and the general condition of the patient become so bad, that the method may have to be abandoned, and the operation concluded under the influence of a general anaesthetic.

CHAPTER X

SPINAL ANALGESIA

THE production of analgesia by means of injections into the spinal canal has been practised for the last few years on the Continent, and the method is now on trial in this country.

Cocaine was first used, but it has been abandoned by most operators for less toxic substances, such as stovaine, tropacocaine, and novocaine.

Stovaine is a synthetic compound made from ethylic alcohol. It is supplied by Billon of Paris in glass bulbs containing as a rule 2 c.c. of a sterilised solution. Various formulae for the solution have been tried, a useful one being that suggested by Barker, who has been the pioneer of the method in this country.

It consists of a 5 per cent. solution of stovaine in distilled water, with 5 per cent. of glucose added to make the solution heavier than the cerebro-spinal fluid. The average dose of this solution is 1 c.c. for an adult, and this contains 5 centigrammes of stovaine. Adrenalin was formerly added to the solution, but it is now omitted, as it is considered to increase headache, which sometimes follows the injection.

Novocaine may be employed in a 5 per cent. solution, an average dose being 2 c.c. of the solution (0·1 gramme of novocaine) for perineal operations, 3 c.c. (0·15 gramme of novocaine) for abdominal operations. It is supplied as

a solution in glass tubes, and also in tablets, a supra-renal extract being contained in both.

Under novocaine, operations in the Trendelenburg position have been successfully performed.

Tropacocaine is used in solutions of 5 or 8 per cent., the average dose being 1 c.c.

Apparatus

The apparatus (Fig. 41) designed by Barker is most

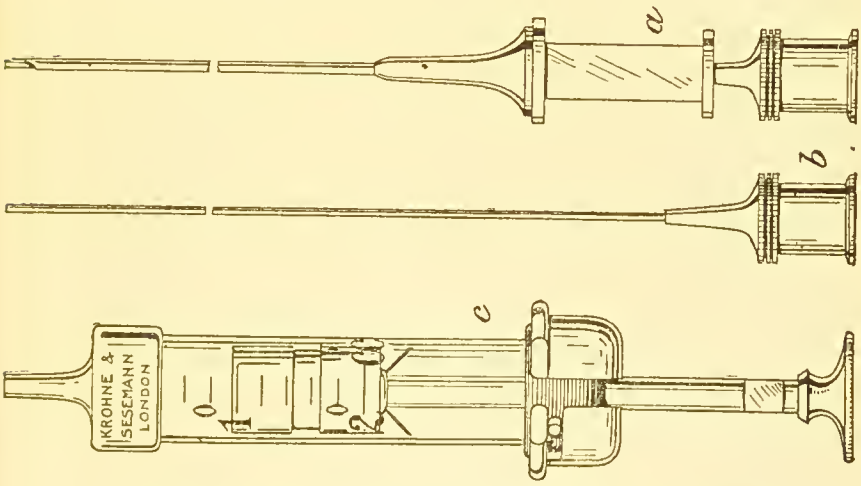

FIG. 41.—BARKER'S APPARATUS FOR SPINAL ANALGESIA. *a*. Needle with cannula in position for injection. *b*. Cannula. *c*. Syringe

suitable. It consists of a glass syringe holding 2 c.c., a strong needle made of nickel, four inches in length, and to fit in the needle a sharp stylet for making the puncture, and a cannula for injecting the fluid. The end of the cannula should project beyond the point of the needle so that when the injection is made no fluid is lost. As stovaine is altered by the action of even small quantities of an alkali, the apparatus should be sterilised by boiling in distilled water.

Preparation of the Patient

This should be carried out in the same manner as for the administration of a general anaesthetic, for in this way sickness and headache are diminished, and there is also no

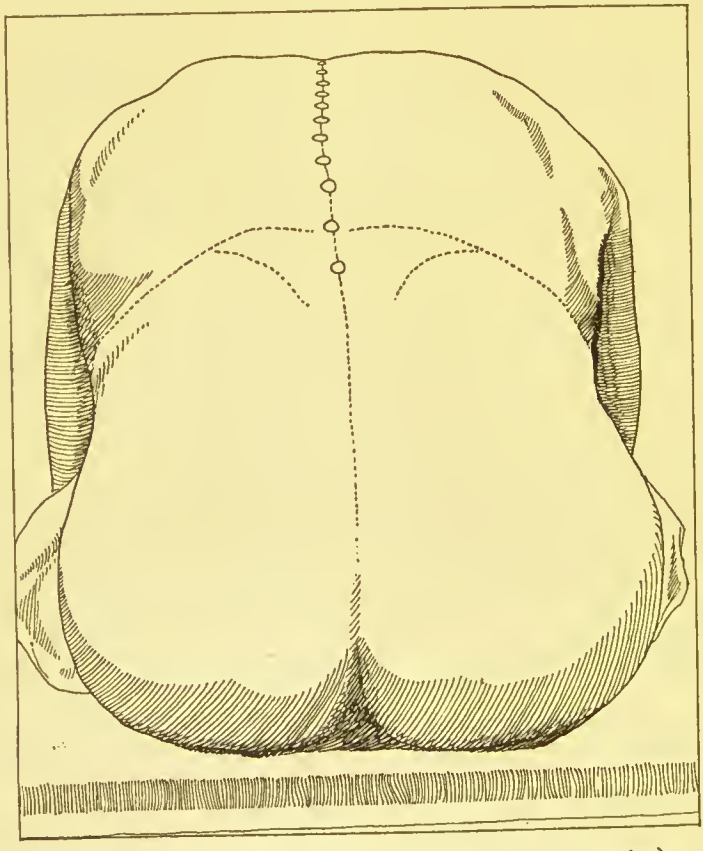

Fig. 42.—The Sitting Position for Injection (after Barker)

certainty that recourse to a general anaesthetic will not become necessary.

In addition, the skin over the seat of puncture must be surgically purified.

Position of the Patient

The two positions most frequently adopted are the sitting and the lateral. In the former the patient sits on the table with the head and shoulders bent well forward (Fig. 42). The puncture is easiest in this position, but it is now only used by Barker for operations in the perineum. In the lateral position the patient lies on one side (Fig. 43), and if the operation is to be confined to one side, on the

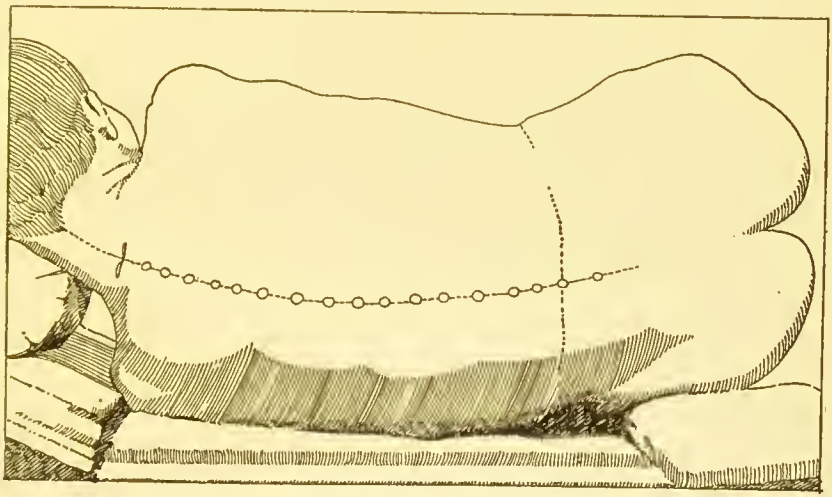

Fig. 43.—The Lateral Position for Injection (after Barker)

side affected, with the knees well drawn up to the abdomen and the pelvis raised by means of a blanket folded in four, or a padded board an inch thick, placed under the trochanter and iliac crest.

The Puncture

The skin being prepared, and the apparatus sterilised, the cannula is fixed to the syringe. The neck of the bulb containing the solution is wiped over with spirit to clean it, and then broken. The solution is then drawn through the cannula into the syringe, the air driven out,

and the solution which is not required for the dose rejected.

A sharp stylet is then placed in the needle in readiness for the puncture.

The iliac crests are first made out and a line drawn between them. This crosses the spinous process of the fourth lumbar vertebra. The puncture is as a rule made just above this, in the third space, but occasionally the second space is chosen, especially when a high analgesia is required.

The skin may be frozen with ethyl chloride before the puncture, but this is not always necessary.

The puncture is generally made in the middle line, care being taken to avoid the spinous process ; but some operators introduce the needle about a quarter of an inch to one side of the spinous process, and then push it upwards, forwards, and towards the middle line.

Barker recommends placing the fingers of the left hand on either side of the spinous process above which the puncture is to be made, so as to exactly define the middle line. He points out that a blunt needle may easily push the dural sac before it instead of puncturing it, and tells the patient to hold his breath at the actual moment of puncturing the sac, as in this way it becomes more tense.

After the needle has been pushed in for about an inch the stylet is removed, and the needle pushed further in till cerebro-spinal fluid, sometimes tinged with blood, begins to drip from it. If no fluid comes the needle should be pressed a little further in, and gently moved about in different directions.

If fluid then does not escape the needle must be withdrawn, and a fresh puncture made. When clear fluid drips freely from the needle, the cannula, which has previously been attached to the syringe containing the dose

of stovaine, should be passed through the needle, and the injection made.

Some surgeons draw about 1 c.c. of cerebro-spinal fluid into the syringe, so that it may mix there with the stovaine solution, and then slowly re-inject the whole. This seems to be quite unnecessary. Others catch the cerebro-spinal fluid in a test tube, and allow it to flow till the quantity collected is equal to that of the stovaine solution to be

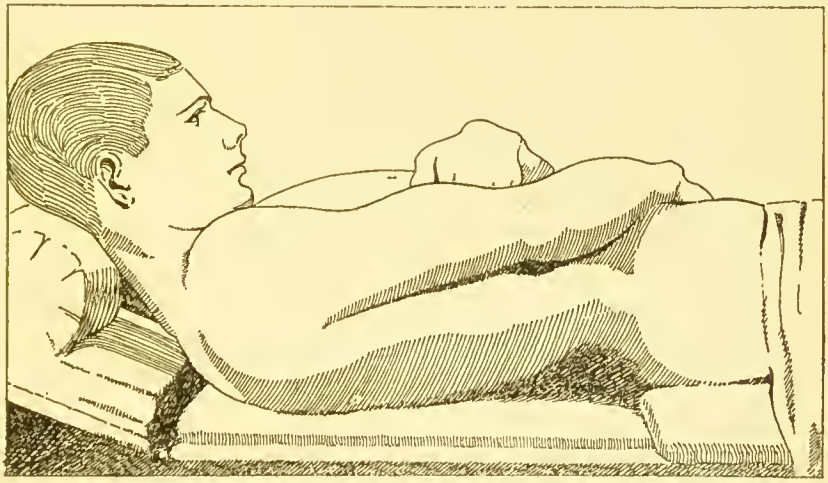

FIG. 44.—POSITION OF PATIENT DURING OPERATION (after Barker)

injected. When all the fluid has been injected the needle is quickly withdrawn, and the wound may be covered with collodion.

The patient is not disturbed for one or two minutes, and is then slowly placed on his back with his head and neck raised on pillows, in the position shown in Fig. 44. He should be instructed to remain quite passive during all movements. If the head and neck are not elevated the analgesia may pass to too high a level, and the inter-costal muscles become paralysed, necessitating artificial respiration. In fact, the height of the analgesia seems to be

determined more by the relative height of the head than the dose of fluid injected.

The patient soon experiences "pins and needles," or tingling, followed by numbness in the legs. Sensation is lost, as a rule, first in the perineum, but soon spreads, the knee jerks are abolished, and the legs cannot be moved. In ten minutes the analgesia has generally reached the level of the umbilicus, and lasts for about an hour.

Analgesia up to the nipple line may easily be obtained, and a few cases have been reported in which it is said to have reached the scalp. By using a heavy solution, that is, one containing more glucose than usual, Barker has been able to obtain analgesia in the left leg when the patient was lying on that side, while the right leg and thigh remained unaffected.

Head considers that analgesia is produced by the action of the drug on the motor and sensory fibres in the spinal canal, or just after they have entered the spinal cord.

Much of the success of the method depends on the care with which the details of the procedure are carried out.

The patient should be warned when the puncture is made, and a screen should be placed before his face so that he may see nothing of the operation. Some Continental surgeons bandage their patients' eyes, and place cotton wool in their ears, while others give morphia half an hour before the injection.

The head and neck should be maintained in the raised position both during the removal from the operating table and for the first few hours in bed.

Advantages and Disadvantages of the Method

The main advantages of spinal analgesia over general anaesthesia are said to consist in the greater relaxation of muscles during some operations, the freedom from after-effects, such as headache, vomiting, etc., the fact that

consciousness is not abolished, and that the amount of shock experienced is small.

It is true that some patients profess a horror of losing their consciousness, but most persons, especially women, prefer to know nothing of the surgical proceedings on their person, and many surgeons prefer to have their patients unconscious. Though no pain may be felt, the condition of the patient on the operating table is not always satisfactory, the pulse becoming small, and the face pale with profuse sweating, and the mental strain to some patients is very real. Vomiting and the evacuation of faeces during the operation are not uncommon.

The *after-effects* may be very slight, though repeated vomiting, very severe headache, and abdominal pain are sometimes experienced. More severe sequelae have been observed, such as retention of urine and paralysis of the sphincter ani, lasting for some days or even months, paralysis of ocular muscles, especially the external rectus, meningitis, gangrene of the feet, paraplegia ending eventually in death, acute mania and cerebral softening. These untoward results have occurred in patients previously healthy, and were, of course, quite unexpected.

The method is certainly one that should never be carried out without proper precautions.

Its relative safety as compared to chloroform cannot yet be accurately determined, but a considerable number of deaths have occurred on the operating table, as well as from after results, and some Continental surgeons are now abandoning this method as a routine practice, and returning to general anaesthesia for all except special cases.

Considerable difficulty is sometimes experienced in making a successful puncture, and even when this has been done analgesia has not always followed, and recourse to a general anaesthetic has become necessary.

At present spinal analgesia is in the experimental stage in this country, and it cannot yet be determined to what extent it will replace general anaesthesia.

It seems more suitable for men than women, and for adults rather than children or elderly persons.

Its greatest use would seem to be for operations below the umbilicus when some condition, such as a severe attack of bronchitis, renders a general anaesthetic specially dangerous to the patient. In cases of grave heart disease it will be hard to decide whether consciousness would not be a greater source of danger to life than the effect of a general anaesthetic.

Operations for intestinal obstruction, and for strangulated hernia, etc., in moribund subjects have been successfully performed under spinal analgesia, and it has been recommended for the setting of fractures of the lower limbs in alcoholic subjects, and especially for amputations of the lower limbs necessitated by accidents.

Most Continental authorities consider that this method should not be used in patients who are septic, on account of the risk of meningitis.

There is no doubt that this method will be of service, and that in the future the apparatus for the production of spinal anaesthesia will be included in the armamentarium of the anaesthetist. But the cases in which it should be employed are not yet defined, and at present there is no certainty in any instance that a general anaesthetic will not be required before the completion of the operation.

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